EVALUATION OF HERBAGE YIELD AND NUTRITIVE VALUE OF EIGHT FORAGE CROP SPECIES

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Abstract. Determining nutritional quality of indigenous forage species constitutes prerequisite to improve the productivity of ruminants. This research was carried out at the research field of the Agricultural Research and Application Center of Igdır University, Turkey in consecutive two years (2015 & 2016) to evaluate the herbage yield and nutritive value of eight forage species having diverse genetic make-up. Eight forage species such as Kentucky bluegrass (*Poa pratensis* var. Geromino), Perennial rye-grass (*Lolium perenne* var. Ovation), Red rescue (*Festuca rubra* rubra var. Corail), Slender creeping red fescue (*Festuca rubra* tricphylla var. Pinafore), Sheep fescue (*Festuca ovina* var. Ridu), Tall fescue (*Festuca arundinaceae* var. Jaguar 4G), Chewings fescue (*Festuca comutata* var. Longfellow II) and Colonial bentgras (*Agrostis tenuis* var. Aristata) were used as plant materials and the experiment was arranged in a randomized complete design with three replications. Data on biomass yield, crude ash, crude protein, crude oil, crude cellulose, net digestible fiber (NDF), acid detergent fiber (ADF), dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were recorded during the investigation. Results of the present study indicated that species ‘Tall fescue’ (*Festuca arundinaceae* var. Jaguar 4G) yielded the highest herbage yield, followed by cultivar ‘Perennial rye-grass’ (*Lolium perenne* var. Ovation). While, ‘Kentucky bluegrass’ (*Poa pratensis* var. Geromino) was found to be inferior to all other forage species in the studied years. When nutritional quality was observed, the species ‘Colonial bentgrass’ (*Agrostis tenuis* var. Aristata) had the maximum crude protein and RFV, while cultivar ‘Perennial rye-grass’ had significantly higher RFV, DMI, DMD and the minimum fiber content, which indicated its superior quality for milch animals.
Keywords: *forage species, Iğdır-Turkey environmental, nutritional quality, yield.*

Abbreviations: ADF: acid detergent fiber; DDM: digestible dry matter; DMI: dry matter intake; NDF: net digestible fiber; RFV: relative feed value

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Introduction

To meet the food demand of increasing population, crop intensification and a sustainability should be continued globally (Jiang and Huang, 2001, Iqbal et al., 2019). The efficient use of farm resources, such as organic manure and home-grown forage, is the key to a sustainable and successful farm operation for the grassland farmers, while to improve the quality of home-grown forage from meadows and pastures, different strategies have been developed (Iqbal et al., 2018). For example, establishment and renovation of grassland by over seeding with high-quality seed mixtures are the most importance task to meet the fodder demand (Poetsch et al., 2016).

Turkey is bestowed with a great number of animals; however, animals' productivity in terms of milk and meat production is very low as compared to their potential. One of the main reasons for this under-performance of animals is owing to deficiency of good quality forages. The most important feed sources are pastures for grazing and those are composed of forage crops such as alfalfa, vetch and sainfoin grown as field crops (Iqbal et al., 2017). Cultivation of forage crops as field crops is rather low in Turkey and areas under forage crop are continuously declining due to increasing demand for food crops. Therefore, it is necessary to expand the forage crops growing area, along with investigating intercropping and crop rotation, as well as developing improved high yielding forage crop species. Although there are some species of vetch and alfalfa, but most of these forage species are perennial grasses; as a result, the number of improved varieties is far beyond the demand (Özpınar et al., 2014).

Among the forage species, 'Kentucky bluegrass' is a common turf species used on golf courses, sports fields, municipal parks, sod farms, road banks, as well as residential and school yards. 'Turfgrass' productivity is largely influenced by fertilization, particularly nitrogen. However, a greater N use efficiency is observed in the soils with low N levels (Below, 1995; Muir et al., 2001; Wims et al., 2013). 'Turfgrass' plants need sufficient soil moisture to maintain normal growth and development. The ornamental value and quality of 'Turfgrass' is severely affected by drought (Kanapeckas et al., 2008). However, the most cool-season 'Turfgrass' species are particularly susceptible to salinity stress during seed germination, with the possible exception of 'perennial ryegrass' (*Lolium perenne* L.). 'Ryegrass' is one of the most important and valuable forage plants in grasslands and constitutes an indispensable component of seed mixtures for meadows, pastures, ley farming, and re-seeding measures (Poetsch et al., 2016). Grazed perennial ryegrass is one of the most important forages for dairy cows in temperate regions due to its high forage yield and nutritive value (van Wijk et al., 1993; Lemus et al., 2008; Kering et al., 2012; Kumar et al., 2016), and hence, provides a cheaper feed than silage or concentrates. Traditionally, perennial ryegrass species were mainly bred for high forage production. Many studies indicated that environmental stresses affected physiological changes, especially antioxidant responses, in many cool-season 'Turfgrass' species (Xu et al., 2006; Senthil-Kumar et al., 2007). The ability for avoiding oxidative stress is a very important factor in determining the environmental stress tolerance of turf-grasses (Wang et al., 2012). Creeping bent-grass (*Agrostis stolonifera* L.) establishment and management practices are well understood for this turf-grass, hence its popularity is widespread (Beard, 2002).

'Red fescue' (*Festuca rubra*), 'Sheep fescue' (*F. ovina*), and 'meadow fescue' (*F. pratensis*) are the subjects of intensive research. All are valued for both forage production and special purposes, ranging from the preparation of sport grounds, parks,

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and house gardens, to preventing the erosion of soil from embankments and railroads (Stanisavljević et al., 2012). 'Tall fescue' has been considered one of the best-adapted cool-season grasses for hot and dry conditions (Turgeon, 1980; Smit et al., 2005a, b).

It is well-established that forage grasses require less intensive management and inputs that impart them superiority over conventional turf blends by reducing the need for fertilization, pest control, irrigation and mowing. The quality of a low maintenance turf is usually not so high, since minimal inputs cannot be expected to produce high quality forage (Prendes and Palencia, 2015). Up-till now, there are a very few studies which provide concrete and conclusive results pertaining to the variability of yield and seed quality including viability of these forage species. It is hypothesized that some of the forage species may outperform others in terms of herbage yield and nutritional quality under Mediterranean environment. Thus, considering the burning issue, the aim of this study was to assess the herbage yield and nutritive value for some forage crop species grown in Mediterranean conditions to meet the quality feed demand for increasing number of cattle.

Materials and methods

Locations and soil properties

This research was carried out at the research field of the Agricultural Research and Application Center, Igdır University, Turkey during consecutive two years (2015 & 2016). Soil of the research site was characterized as clay-loamy texture, highly alkaline (pH: 8.6), lightly salted (EC: 1.37 dS/m), low organic matter content (1.20%) and rich in lime ($CaCO_3$: 22.27%). Beside these, available phosphorus (P) and potassium (K) contents in the soil were found to be 51.7 ppm and 852.4 ppm (Erdogan, 2013).

Treatments and experimental design and using materials

Selected eight forage species such as Kentucky bluegrass (*Poa pratensis* var. Geromino), Perennial rye-grass (*Lolium perenne* var. Ovation), Red rescue (*Festuca rubra* rubra var. Corail), Slender creeping red fescue (*Festuca rubra* tricphylla var. Pinafore), Sheep fescue (*Festuca ovina* var. Ridu), Tall fescue (*Festuca arundinaceae* var. Jaguar 4G), Chewings fescue (*Festuca comutata* var. Longfellow II) and Colonial bentgras (*Agrostis tenuis* var. Aristata) were arranged in a randomized complete design with three replications. Each experimental plot had the net area of 12 m^2 (3 × 4 m). The list of the forage crops under investigation are described in *Table 1*.

Table 1. *Forage crops used in the experiment*

SL No.	English name	Latin name
1.	Kentucky bluegrass	*Poa pratensis* var. Geromino
2.	Perennial rye-grass	*Lolium perenne* var. Ovation
3.	Red rescue	*Festuca rubra* rubra var. Corail
4.	Slender creeping red fescue	*Festuca rubra* tricphylla var. Pinafore
5.	Sheep fescue	*Festuca ovina* var. Ridu
6.	Tall fescue	*Festuca arundinaceae* var. Jaguar 4G
7.	Chewings fescue	*Festuca comutata* var. Longfellow II
8.	Colonial bentgras	*Agrostis tenuis* var. Aristata

Experimental procedure

In the first year, 5 kg nitrogen (N) and 8 kg phosphorus da^{-1} were applied in all plots during the final land preparation. In the second year, 15 kg da^{-1} nitrogen was applied to all plots. while half of the nitrogen was applied during April and May each year. During first year, seeds of all forage species were sown on 15 March 2014 and no yield could be recorded in this year. Therefore, the data obtained in the first year of the establishing were not taken into consideration and only the second and third year data were evaluated. Irrigation was applied as per field capacity. Cutting time was June 15, 2015 in the second year and June 20, 2016 the third year. After leaving 0.5 m from the sides of each plots l, the rest of the plots (6 m^2) were cut with a machine called ‘Figaro’ and were weighed immediately using spring balance. Since the first year is the establishing year, the second and third year data are taken into consideration and subsequently analyzed statistically.

Chemical analyses

Chemical analyses regarding crude protein (CP) and ash concentration were performed as per procedures outlined by AOAC (2000). Neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose and lignin were determined by following Van Soest et al. (1991) using Fiber Tech analyzer (FibraPlus FES 6, Pelican, Chennai, India). Heat-labile α-amylase and sodium sulphite were used in NDF solution. Lignin (sa) was determined by dissolving cellulose with sulfuric acid in the ADF residue (Van Soest et al., 1991). Cellulose was estimated as the difference between ADF and lignin (sa) in the sequential analysis and hemicellulose was calculated as difference between NDF and ADF concentrations. Dry matter intake (DMI), digestible of dry matter (DDM), relative feed value (RFV) for different animal functions was determined as described by Undersander et al. (1993).

Statistical analysis

The obtained data were statistically analyzed, separately and combined, using “SAS” statistical package program. Variable means were compared at the significance level of $P < 0.05$. Correlation coefficients between different yield attributes were done by using the same statistical software (Snedecor and Cochran, 1994).

Results and discussion

Dry hay yield of different forage species

It was revealed that ‘tall fescue’ performed the best over other forage species under study in terms of dry matter yield, this result is in agreement with the finding of Campbell and Xia (2002). Forage cultivars ‘Perennial rye-grass’ and ‘slender creeping red fescue’ followed ‘tall fescue’ in terms of herbage yield in both years. ‘Kentucky bluegrass’ and ‘colonial bentgras’ yielded the minimum hay (*Fig. 1; Table 2*). The significantly higher herbage yield contributed by ‘tall fescue’ might be attributed to significantly higher plant height and fast regrowth rate after cutting. In addition to this, early and strong spring growth could have positive effect on it (Özpınar et al., 2014, Campbell and Xia, 2002). To achieve appropriate yield and quality herbage and change

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greatly depending on cultural practice, the species, variety and environment (Barutcular et al., 2017; Akdeniz et al., 2018a).

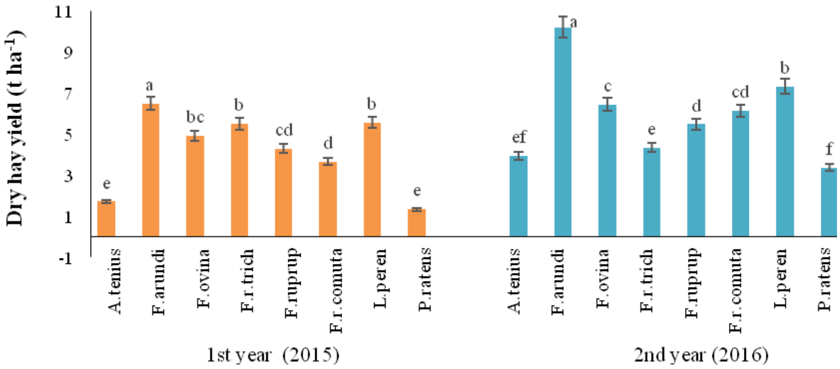

***Figure 1.** Dry hay yield (t ha^{-1}) of different forage species grown under the Mediterranean environment of Turkey during 2015 and 2016. Bar with same letter indicates that does not differ significantly, while with dissimilar letters indicates that differ significantly. Mean (±SE) was calculated from three replicates for each forage cultivars. Error bars represent significant difference at $p \leq 0.01$ (LSD test)*

***Table 2.** Dry biomass yield and nutritional quality of hay of different forage species grown under Mediterranean environment during 2015 and 2016*

Forage species	Dry hay yield (t ha^{-1})	Crude ash (%)	Crude protein (%)	Crude oil (%)	Crude cellulose (%)	NDF (%)	ADF (%)	DMI	DDM	RFV
	First year									
A. tenius	1.71e	17.12b	21.06a	1.67abc	39.94bc	52.45bc	35.33de	2.29ab	61.38	109.06ab
F. arundi	6.50a	22.17a	15.84c	1.07cd	61.25a	62.89a	39.10cd	1.91c	58.44	86.45cd
F. ovina	4.93bc	10.43cd	13.59de	1.56bc	36.59cd	61.33a	43.19ab	1.96c	55.23	84.28d
F. r. trich	5.50b	17.99b	14.143cde	0.74d	65.81a	64.00a	45.78a	1.88c	50.64	73.67d
F. ruprup	4.30cd	18.06b	15.60c	0.75d	38.26bcd	63.71a	39.76bc	1.89c	57.93	84.72d
F. r. comuta	3.66d	11.09c	13.30e	0.74d	42.48b	64.28a	40.62bc	1.87c	57.26	82.99d
L. peren	5.57b	19.00b	17.92b	2.29a	33.59d	49.33c	32.88e	2.43a	63.28	119.41a
P. ratens	1.33e	8.39d	15.25cd	1.91ab	42.70b	55.79b	37.27cd	2.15b	59.87	99.94bc
LSD $_{(0.05)}$	0.65	2.44	1.77	0.70	5.36	4.29	4.07	0.15	ns	14.32
	Second year									
A. tenius	3.94ef	7.51c	10.45b	1.60	36.77e	41.17d	24.93c	4.82a	56.83b	212.09b
F. arundi	10.23a	9.54a	9.86bc	1.15	44.85a	64.05c	47.64a	1.87bc	51.79d	75.22cd
F. ovina	6.46c	5.57d	5.80e	1.41	44.06ab	68.33b	45.58ab	1.76cd	53.39cd	72.71d
F. r. trich	4.337e	8.49b	8.85bcd	1.44	43.612abc	69.25b	44.26b	1.73cd	54.42c	73.11d
F. ruprup	5.48d	6.98c	7.91d	0.96	41.47cd	70.29b	46.31ab	1.71d	52.83cd	69.91d
F. r. comuta	6.13cd	5.44d	8.52cd	1.02	41.61bcd	83.25a	45.21ab	1.44e	53.68cd	59.99e
L. peren	7.33b	9.13ab	12.75a	1.52	36.33e	35.51e	24.82c	4.84a	61.24a	229.76a
P. ratens	3.36f	8.73ab	9.74bc	1.53	40.77d	62.63c	43.97b	1.92b	54.65c	81.19c
LSD $_{(0.05)}$	0.72	0.81	1.63	ns	2.49	2.20	2.49	0.15	1.99	7.38

NDF: neutral detergent fiber; ADF: acid detergent fiber; DMI: intake, digestibility to calculate DM intake; DDM: digestible dry matter; RFV: relative feed value

Crude protein, crude ash, oil content, NDF, ADF and cellulose

Ash, oil content, NDF, ADF and cellulose were found to be varying among the species under investigation (*Figs. 2* and *3; Table 2*). However, 'Colonial bentgras'

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proved to be superior to all in terms of crude protein content and it was followed by 'perennial rye-grass'. The minimum crude protein content was recorded by 'sheep fescue' followed by 'chewings fescue'. On the other hand, 'tall fescue' had the maximum ash and was closely followed by 'perennial rye-grass', 'slender creeping red fescue', 'red rescue. Chewings fescue' recorded the lowest crude oil content while 'perennial rye-grass' had quite high oil concentration. 'Perennial rye-grass' remained outstanding by recording the lowest cellulose and NDF as well as ADF contents (*Fig. 3; Table 2*).

Cereal stover and straws are usually low in crude protein and rich in fiber concentrations, and thus unable to meet the minimum crude protein requirements (7%) for maintenance of animals and rumen microbes (Minson, 1990). There is a dire need to supplement this stover with protein rich leguminous forage or non-protein nitrogen or protein sources in order to obtain sustainable supplies of milk from dairy animals. It was observed significant differences among the crops and their interaction with environment regarding yield and quality properties However, variations have been also observed in different agronomic and quality were also noted by Barutcular et al. (2016a, b, c; Akdeniz et al., 2018b; Yıldırım et al.,2018). The variability in NDF, ADF, cellulose and lignin concentrations of sorghum stover in different species has been reported earlier (Hamed et al., 2015) and it is reported that forage with high NDF levels had higher concentrations of the CB2 fraction, which is more slowly degraded in the rumen, impacting microbial synthesis and animal performance (Ribeiro et al., 2001). Carvalho et al. (2007) reported that NDF concentration influences carbohydrate fraction CB2 and forages high in NDF concentration usually have higher values of CB2.

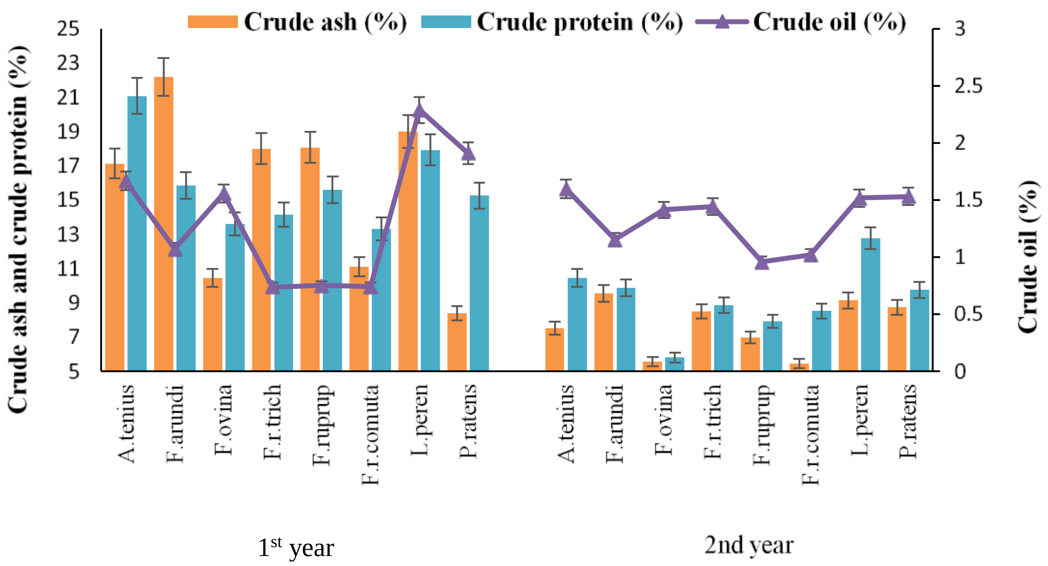

Figure 2. *Crude ash, crude protein and crude oil of hay/forage as influenced by different forage species grown under Mediterranean environment*

Intake, digestibility and relative feed value

The calculated values of DMI, DDM and RFV for different forage crops varied significantly during both years of study (*Fig. 4*). 'Perennial rye-grass' proved its superiority to other forage species by recording the highest DMI, DMD and RFV, while

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it was followed by ‘colonial bentgras’. It was also revealed that ‘kentucky bluegrass’ was better than ‘slender creeping red fescue’, ‘red rescue’ and ‘chewings fescue’, but remained inferior to ‘perennial rye-grass’ and ‘Colonial bentgras’. Dietary fiber concentration, its digestibility and rate of degradation in the rumen are the most important forage characteristics that determine DMI (Roche et al., 2008). We attributed the lower RFV of stover in the present study to its lower quality relative to the whole plants examined at the younger age which is agreement with Bean et al. (2011), who noted that higher NDF and ADF concentrations influence the intake and digestibility of a fodder.

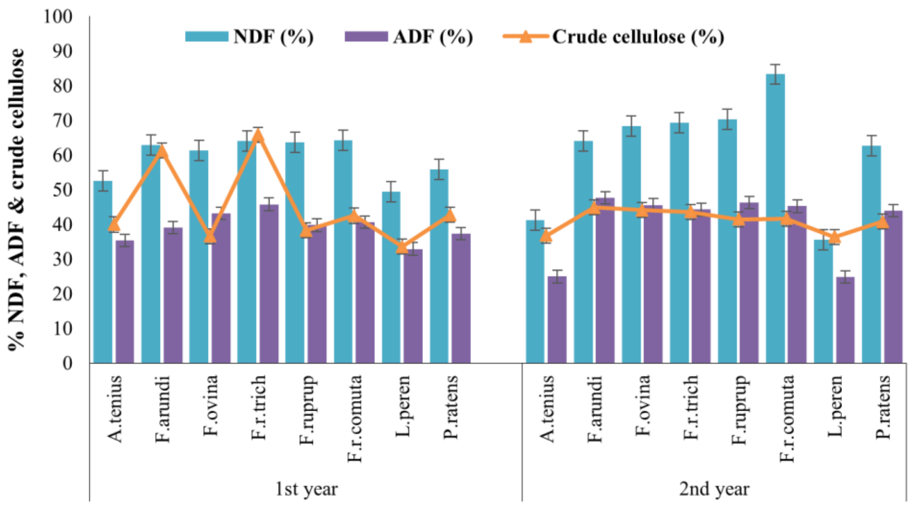

Figure 3. *Acid detergent fiber (ADF), neutral detergent fiber (NDF) and crude cellulose of hay/forage as influenced by different forage species grown under Mediterranean environment*

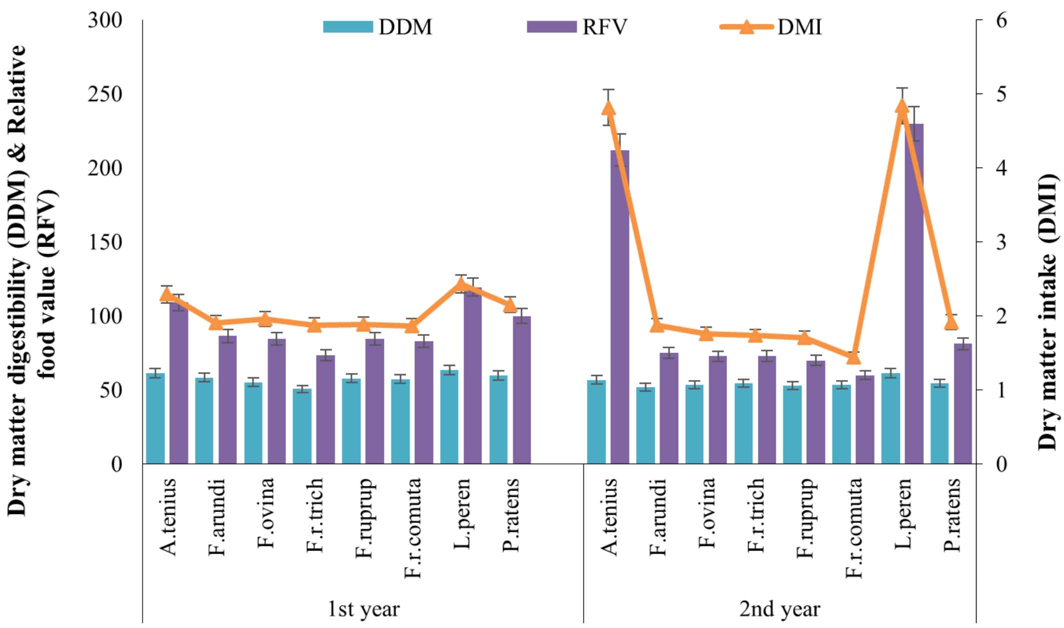

Figure 4. *Intake, digestibility and relative value of dry hay/forage as influenced by different forage species grown under Mediterranean environment*

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Correlation coefficients among the different variables

Correlation coefficients among the variables under study were found to be significant (*Table 3*). In the present study, dry yield was positively correlated with ADF and NDF, while ADF remained positively correlated with NDF. The findings are in confirmation with those of Badrzadeh (2008), who reported ADF direct relationship with NDF. On the other hand, the NDF was negatively correlated with the DDM and RFV. The ADF was negative correlated with DMI, DDM and RFV. Genotypic differences in terms of all quality parameters were found significant, while ADF ratio was non-significant, our results are in accordance with the findings of (Yılmaz and Erol, 2015). Bani et al. (2007) recorded an inverse relationship between forage fiber fractions and DM digestibility.

Table 3. *Correlation coefficients between different studied parameters*

Study parameters	Dry yield ($t\ ha^{-1}$)	Crude ash (%)	Crude protein (%)	Crude oil (%)	Crude cellulose (%)	NDF (%)	ADF (%)	Crude ash yield ($t\ ha^{-1}$)	Protein yield ($t\ ha^{-1}$)	Crude oil ($t\ ha^{-1}$)	NDF ($t\ ha^{-1}$)	ADF ($t\ ha^{-1}$)	Dry matter intake	Digestible dry matter
	1st year													
Crude ash, %	0.608													
Crude protein, %	-0.328	0.427												
Crude oil, %	-0.273	-0.169	0.513											
Crude cellulose, %	0.407	0.406	-0.268	-0.544										
NDF, %	0.354	-0.032	-0.762*	-0.917**	0.520									
ADF, %	0.317	-0.169	-0.751*	-0.724*	0.555	0.847**								
Crude ash yield, t/ha	0.913**	0.840**	-0.047	-0.220	0.519	0.207	0.091							
Protein yield, t/ha	0.959**	0.744*	-0.075	-0.089	0.308	0.115	0.055	0.954**						
Crude oil, yield/ha	0.636	0.352	0.117	0.543	-0.208	-0.431	-0.336	0.565	0.748*					
NDF, t/ha	0.973**	0.562	-0.443	-0.463	0.524	0.550	0.487	0.877**	0.884**	0.451				
ADF, t/ha	0.965**	0.515	-0.465	-0.438	0.535	0.534	0.550	0.840**	0.863**	0.462	0.989**			
Dry matter intake	-0.318	0.061	0.760*	0.906**	-0.522	-0.998**	-0.851**	-0.175	-0.077	0.460	-0.520	-0.504		
Digestible dry matter	-0.332	0.093	0.688	0.699	-0.629	-0.783*	-0.983**	-0.138	-0.088	0.313	-0.487	-0.562	0.783*	
Relative feed value	-0.328	0.084	0.773*	0.875**	-0.589	-0.972**	-0.945**	-0.161	-0.073	0.440	-0.525	-0.542	0.974**	0.903**
	2nd year													
Crude ash, %	0.210													
Crude protein, %	0.100	0.720*												
Crude oil, %	-0.411	0.357	0.386											
Crude cellulose, %	0.334	-0.146	-0.705	-0.459										
NDF, %	0.016	-0.523	-0.747*	-0.693	0.779*									
ADF, %	0.174	-0.240	-0.717*	-0.624	0.919**	0.905**								
Crude ash yield, t/ha	0.906**	0.601	0.396	-0.192	0.201	-0.218	0.029							
Protein yield, t/ha	0.864**	0.541	0.585	-0.146	-0.074	-0.355	-0.209	0.939**						
Crude oil, yield/ha	0.867**	0.378	0.327	0.081	0.068	-0.373	-0.186	0.862**	0.871**					
NDF, t/ha	0.808*	-0.161	-0.375	-0.728*	0.720*	0.587	0.654	0.592	0.468	0.466				
ADF, t/ha	0.872**	0.043	-0.283	-0.617	0.716*	0.441	0.610	0.732*	0.566	0.583	0.967**			
Dry matter intake	-0.070	0.321	0.737*	0.610	-0.883**	-0.950**	-0.987**	0.093	0.302	0.283	-0.590	-0.514		
Digestible dry matter	-0.154	0.298	0.748*	0.613	-0.862**	-0.822*	-0.898**	-0.008	0.259	0.236	-0.645	-0.610	0.863**	
Relative feed value	-0.060	0.327	0.753*	0.607	-0.890**	-0.949**	-0.989**	0.101	0.320	0.299	-0.590	-0.517	0.998**	0.893**

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Conclusion

The results from this study revealed that significant variability exists among forage species under study in terms of their potential for herbage yield and nutritive value under Mediterranean environment. This indicates that there is a considerable potential for selecting appropriate forage species, which have the adequate nutritional quality to improve forage supply for as well as to meeting ruminant dietary requirements. It is clear that the potentiality of *Festuca* species as forage and pasture plants under prevalent agro-climatic conditions is very high due to specific nutritional characteristics. *F. arundinacea* can also be promoted as forage and pasture specie due to higher potential to yield dry matter while using *F. rubra* as a pasture plants to improve natural grassland seems to be more suitable.

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