

Original Research

# The Effect of Mowings on the Nutritional Value of Annual Ryegrass (*Lolium multiflorum* Lam) Varieties Grown in Different Agroclimatic Conditions of Central Anatolia

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## Abstract

Annual ryegrass (*Lolium multiflorum* Lam.) is an important multipurpose forage grass crop of Türkiye. The aim of the study was to compare the yield potential of 5 local and exotic cultivars (Trinova, Vivaro, Elif, Caramba and Grasslands Bill) for their adaptability and appropriateness to long and short-term practices at Konya and Ankara locations of Central Anatolia during 2020-2021. Plant height, ADF, NDF, crude protein ratio, dry matter digestibility, relative feed value, fresh and dry forage yields, and crude protein yield were evaluated and compared. The highest dry forage yield in all three mowings was obtained from Caramba (1 mowing: 9869 kg ha<sup>-1</sup>, 2 mowings: 17681 kg ha<sup>-1</sup>, and 3 mowings: 22154 kg ha<sup>-1</sup>) at Konya location whereas, highest dry forage yield was obtained from Trinova with a maximum yield of 10452 kg ha<sup>-1</sup> while the difference in total dry forage yield among other cultivars was statistically non significant for 2 and 3 mowings at Ankara location. This study meets objectives by identifying varied potentials of the cultivars, and their suitability in hot and humid continental climate of Ankara and cold semi-arid climate of Konya in Central Anatolia.

**Keywords:** ADF, climatic factors, crude protein ratio, dry matter, NDF

## Introduction

Ryegrass is a very small genus of 8 species [1-3]. All of them are diploid with a chromosome number of  $2n = 2x = 14$ . The plant is valued as a forage crop due to its high nutrient contents, digestibility, and taste for animals. It is also used as medicinal plant, [4], lawn grass in ornamental plants, and soil conservation [5, 6]. There is a need to improve its agronomic cultivation techniques to maintain quality and improve yield [7, 8].

Turkish farmers are showing an increased interest in beef cattle farming with effective harvest and mowing of fresh green forage in summer for more than one time and dry dry forage in the winter and eliminating the roughage deficit [2, 9, 10, 11]. Under ideal conditions, it is possible to harvest 15000-25000 kg of fresh and 5000-8000 kg ha<sup>-1</sup> of dry matter under irrigated conditions. It can 40-60 tons/ha of fresh and 7500-15000 kg ha<sup>-1</sup> of dry forage with 2-3 harvests under rainfed conditions [2, 12].

There is a need to select genetically stable plants by evaluating them in contrasting habitats to observe genetic stability during breeding and maintain purity.

The aim of the study was to determine the adaptation level of *L. multiflorum* cultivars under two distinguished ecological niches of Ankara location (Hot humid continental climate D<sub>Sa</sub>, 39°57' north latitude, 32°52' east longitude) and Konya (38°01'47 north latitude and 32°30'37 east longitude) with cold semi-arid climate (B<sub>Sk</sub>) in terms of selection for variation in adaptability during 2020 and 2021 growing season.

## Material and Methods

The experimental material consisted of 5 *L. multiflorum* cultivars namely "Trinova, Vivaro, Elif, Caramba and Grasslands Bill (GB)." The material was received from different seed companies located at Ankara.

### Climatic Conditions

The precipitation, temperature, and relative humidity of these areas for long years and 2020-2021 are given in Table 1.

#### Ankara Location

The total annual precipitation was 355.8 mm in 2020, and 349.1 mm in the following year, which was lower than the long-term mean (391.8 mm). The mean annual temperature value at the Ankara location for long years was 11.9°C. The mean temperature value for 2020 was 14.1°C and 13.4°C for 2021, which is higher than the mean temperature values for long years. Annual mean relative humidity values were 52.1% and 55.6% during 2020 and 2021 in the same order, which was lower than the long-term means of 60.1%.

#### Konya Location

A total precipitation of 303.6 mm was noted in the first year and 315.6 mm in the following year (Table 1). It was lower compared to the mean precipitation (332.8 mm) for long years. The mean temperature values for 2020 and 2021, were 14.7°C and 14.1°C, in the same order, and were above the mean temperature values for long years. Annual mean relative humidity values, at Konya was 53.0%, and 53.3% for 2020, and 2021, in the same sequence, which was lower than the long-term means of 54.6%.

### Soil Characteristics of the Research Areas

#### Ankara Location

The experimental area was salt free and had a clay-loam structure. The soils were slight alkaline, moderately calcareous, low in phosphorus, high in potassium, and low in organic matter (Table 2).

#### Konya Location

The soils of the experimental area at Konya were clay-loam in texture with alkaline properties. Organic matter content was 1.12%, EC (µS/cm) of 190, P<sub>2</sub>O<sub>5</sub> = 10.58 mg kg<sup>-1</sup>, K<sub>2</sub>O = 242.36 mg kg<sup>-1</sup>, Na = 67.02 mg kg<sup>-1</sup>, Ca = 5600 mg kg<sup>-1</sup>, Zn = 2.13 mg kg<sup>-1</sup>, Mn = 4.80 mg kg<sup>-1</sup>, Cu = 0.81 mg kg<sup>-1</sup>, and Fe = 1.30 mg kg<sup>-1</sup>.

### Experimental Design and Sowing

The experiment was established during autumn of 2020 in four replications, using a randomized block design. The sowing of *L. multiflorum* cultivars was carried out at Ankara, and Konya locations simultaneously on September 30, 2020, at a depth of 2-3 cm. Sowing was carried out manually in 6 rows of 5 m length manually maintaining a distance of 25 cm among rows. Similarly, a distance of 50 cm was maintained among blocks. The external rows at the beginning and the end of each plot were not included during the taking of the data to avoid the effect of edges.

The first, 2<sup>nd</sup> and 3<sup>rd</sup> mowings were carried out on 12 May, 15 June, and 12 July of 2021 at both locations.

P<sub>2</sub>O<sub>5</sub> (100 kg ha<sup>-1</sup>) and N (50 kg ha<sup>-1</sup>) were applied at the time of autumn sowing. It was followed by (50 kg ha<sup>-1</sup>) N fertilization during spring and after each mowing. Significant differences were noted among the species, when they were harvested in between earing and flowering [2, 13]. Fresh forage yield (FFY) was determined according to Çolak and Sancak [14] by mowing and weighing during the heading period when *L. multiflorum* is the most productive and nutritious. Dry matter yields (DMY) were determined by taking 500 g samples from each plot, drying them at 70°C for 48 hours, and weighing them using a digital scale

Table 1. Climate data of Ankara and Konya experimental locations for the year 2020-2021 and for long years\*.

Months	Monthly total precipitation			Monthly mean temperature (°C)			Monthly mean relative humidity (%)		
	Long term mean	2020	2021	Long term mean	2020	2021	Long term mean	2020	2021
	Ankara								
January	40.3	20.6	64.2	0.2	1.4	3.5	77.3	72.8	74.1
February	35.3	64.7	10.0	1.7	4.2	4.5	72.7	66.2	60.5
March	39.3	21.2	63.2	5.7	9.3	5.1	64.4	56.4	62.7
April	42.2	22.1	28.0	11.2	11.7	12.3	58.4	47.4	54.9
May	51.3	65.2	13.9	16.1	17.0	19.1	56.7	48.9	39.7
June	35.2	103.3	41.0	20.0	20.7	19.0	51.8	50.9	57.4
July	14.1	5.3	2.0	23.4	25.9	25.5	44.2	37.4	37.2
August	12.5	0.0	12.8	23.4	25.3	25.7	42.9	30.5	34.9
September	18.0	4.5	24.3	18.9	23.4	18.7	47.7	37.8	48.2
October	27.5	27.8	4.4	13.2	17.7	13.3	58.5	45.3	50.2
November	31.5	5.1	45.7	7.3	6.8	9.3	69.7	60.2	70.1
December	44.6	16.0	39.6	2.5	6.0	4.3	77.6	71.1	77.3
Mean/Total	391.8	355.8	349.1	11.9	14.1	13.4	60.2	52.1	55.6
Konya									
January	34.8	62.6	29.6	1.5	1.8	4.4	76.1	69.9	69.0
February	22.8	36.8	7.4	3.7	4.5	5.1	67.4	64.8	58.7
March	27.4	37.6	56.4	8.1	8.9	6.3	56.6	59.7	60.0
April	33.5	36.4	29.6	12.7	12.6	13.6	50.6	52.8	49.7
May	37.1	36.0	1.2	17.6	18.0	20.7	48.3	46.6	38.3
June	27.8	32.8	49.0	21.7	21.9	20.4	45.0	44.4	52.3
July	7.5	0.0	1.8	25.4	26.9	25.9	34.9	35.7	38.4
August	6.6	7.8	5.2	25.4	25.5	25.7	35.3	33.1	37.6
September	16.7	10.4	33.6	20.5	23.9	19.4	41.3	42.6	49.9
October	29.6	12.2	0.0	14.3	18.4	14.1	56.4	50.8	49.2
November	33.5	19.2	25.6	7.8	7.7	10.1	66.8	64.8	63.1
December	55.5	11.8	76.2	3.2	6.6	3.7	77.1	71.1	73.9
Mean/Total	332.8	303.6	315.6	13.5	14.7	14.1	54.6	53.0	53.3

\* Directorate General of the Meteorology, T.R. Ministry of Environment, Urbanization and Climate Change

[15]. Crude protein yield (CPY) was determined by multiplying the dry forage yields determined in the plots with the crude protein content percentages found as a result of the laboratory analysis [14]. Crude protein content was determined by the Kjeldahl method following Kacar and İnal [16]. In order to determine the dry matter production, the samples taken from each plot were ground using hay mill following taking of 0.3-0.5 g samples. The total nitrogen percentage in the dry matter samples was used to calculate the crude protein percentage after wet burning.

The crude protein percentage was calculated by multiplying the total nitrogen with the coefficient of 6.25. Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) contents were determined according to Kutlu [17] and Bender et.al [18]. They were calculated as described for ANKOM technology with the help of Fiber Analyzer device.

Statistical analysis was carried out using the MSTATC computer software. The means were compared using Duncan's Multiple Range Test (DMRT).

Table 2. Effects of *L. multiflorum* cultivars on PH, CP, ADF and NDF percentage (%) of different Locations and different harvest periods\*.

Cultivar	Ankara location				Konya location				Means
	1 <sup>st</sup> mowing	2 <sup>nd</sup> mowing	3 <sup>rd</sup> mowing	Means	1 <sup>st</sup> mowing	2 <sup>nd</sup> mowing	3 <sup>rd</sup> mowing	Means	
	Plant height (PH) cm								
Trinova	128.8 a	76.5 ab	41.0 ab	82.1	87.5 c	66.8	58.8 bc	71.0	76.5
Vivaro	108.3 bc	79.0 ab	46.2 ab	77.8	94.0 bc	75.25	67.8 ab	79.0	78.4
Elif	109.3 bc	80.7 ab	47.8 a	79.2	105.0 a	71.75	67.5 ab	81.4	80.3
Caramba	103.3 c	72.8 b	46.8 a	74.2	97.0 ab	73.50	71.0 a	80.5	77.4
GB	116.0 b	83.0 a	37.5 b	78.8	77.8 d	67.00	55.8 c	66.8	72.8
Mean	113.14	78.4	43.85		92.25	70.85	64.15		
	Crude protein (CP) percentage %								
Trinova	9.2	14.7	16.9	13.6	15.9	17.3	16.9	16.7	15.2 a
Vivaro	9.7	12.9	17.0	13.2	15.9	16.4	15.1	15.8	14.5 ab
Elif	8.7	13.9	16.9	13.2	15.0	15.8	15.9	15.6	14.4 ab
Caramba	9.1	12.8	15.9	12.6	15.4	17.1	13.3	15.3	13.9 b
GB	8.6	14.0	15.6	13.0	15.6	17.1	16.2	16.3	14.7 ab
Means	9.0 c	13.9 b	16.7 a		15.6 b	16.7 a	15.5 b		
	Acid detergent fiber (ADF) %								
Trinova	26.2	26.6	22.2	25.0 a	28.3	28.3	28.1	28.2 b	26.6
Vivaro	24.2	24.7	21.3	23.4 b	27.5	28.8	29.8	28.7 ab	26.1
Elif	25.3	25.5	21.6	24.2 ab	28.2	31.0	26.5	28.6 b	26.4
Caramba	24.4	24.7	21.4	23.5 b	28.5	28.9	32.0	29.8 a	26.7
GB	25.4	25.3	22.0	24.2 ab	28.2	29.3	30.4	29.3 ab	26.8
Mean	25.1 a	25.4 a	21.7 b		28.2	29.3	29.4		
	Neutral detergent fiber (NDF) %								
Trinova	47.2	48.1	47.0	47.4 a	49.3	46.6	48.1	48.0 b	47.7
Vivaro	46.0	46.8	44.2	45.7 bc	47.6	47.6	53.0	49.4 ab	47.5
Elif	45.6	48.2	45.9	46.6 ab	47.0	50.1	48.8	48.6 ab	47.6
Caramba	44.4	45.8	44.1	44.8 c	49.7	47.2	52.2	49.7 a	47.2
GB	44.7	46.4	45.7	45.6 bc	49.5	48.5	51.0	49.6 ab	47.6
Mean	45.6	47.1	45.4		48.7 ab	48.0 b	50.6 a		

\* All values shown by different letters in rows or columns are statistically different within the error limits of  $p < 0.05$  according to Duncan's MRT

## Results

The data on plant height (cm), crude protein percentage (%), Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were analyzed separately for all three mowings in the study (Table 2). The results of the *L. multiflorum*, dry forage, and crude protein yields were compared for first

second and third mowing values individually and by taking cumulative means of the three mowings (Table 3).

### Plant Height (cm)

A 3-way significant cultivar  $\times$  mowing  $\times$  location interaction was noted ( $p < 0.05$ -Table 1) for two different

locations; when *L. multiflorum* cultivars were considered in terms of their height at maturity.

Ankara: A comparison of the results at the first mowing stages showed that cv Trinova attained the maximum height of 128.8 cm. The plant height of cv. GB, Elif, and Vivaro at the 1<sup>st</sup> mowing was statistically similar and the minimum height was observed for cv. Caramba with a length of 103.3 cm.

#### Konya

Maximum plant height for all cultivars was noted after the first mowing. This ranged 105.0 cm (Cv. Elif) to 77.8 cm (GB). Non-significant differences were observed in the second mowing for all cultivars. Minimum plant height was noted at the time of the third mowing with a range of 71.0 cm (Caramba) to 55.8 cm (GB).

#### Acid Detergent Fiber (ADF)

Locations and cultivars had statistically different effects on the rate of ADF in *L. multiflorum* (Table 2).

A statistical difference ( $p < 0.05$ ) was found among the ADF means of the cultivars in all mowings at the Ankara location. The maximum of 25.4% ADF content was obtained in the second mowing and was statistically similar to 25.1% ADF content in the first mowing. The minimum ADF percentage of 21.7% was obtained from the third mowing. Although 28.9% ADF in dry matter at the Konya location of the study was higher compared to the Ankara location (24.1%), both of them were statistically similar.

The maximum ADF percentage of 25.0% was found in cv. Trinova at Ankara location. The minimum ADF percentage of 23.40% was found in cv. Caramba, which was statistically similar to the values obtained for cv. Vivaro (23.50%). Similarly, the highest ADF percentage was found in cv. Caramba (29.82%) at the Konya location. The minimum ADF percentage was determined in cv. Trinova (28.22%). The mean ADF values at Ankara and Konya locations were 24.07% and 28.92%, in the same order.

#### Neutral Detergent Fiber (NDF)

The location and cultivars had a statistically significant ( $p < 0.05$ ) effect on the NDF percentage of *L. multiflorum* dry matter contents (Table 2).

The NDF values of the dry matter of the cultivars were statistically similar within the experiment at each location in the experiments conducted at Ankara and Konya locations. The maximum values were determined as 47.42% in cv. Trinova for Ankara location and 49.72% in cv. Caramba for Konya location. Considering the means of three mowings at Ankara and Konya locations, the differences between the NDF percentages in the dry matter among the cultivars were statistically significant the maximum NDF value of 47.4%, was obtained from cv. Trinova at the Ankara location, while the minimum

NDF value was obtained from cv. Caramba with a value of 44.8%.

The maximum NDF value (49.7%) was found in cv. Caramba at Konya location showing statistically similar results with the values obtained for cv. Vivaro, Elif and GB. The minimum NDF value of 48.0% at Konya was found in cv. Trinova.

#### Crude Protein Percentage

Crude protein percentage varied significantly among the cultivars and the mowing means at the locations, while the locations did not significantly affect the crude protein percentage (Table 2).

It was determined that cv. Trinova, Vivaro, Elif, and Grassland were statistically similar, but the crude protein percentage of the dry matter of cv. Trinova, and 15.2% Caramba was 13.9% respectively. The maximum crude protein percentage was obtained with a value of 16.7%, in the third mowing at Ankara location, which was statistically similar to the mowing values obtained at Konya location. Although the lowest crude protein of 9% was obtained from the first mowing at the Ankara location and the third mowing with 15.5% value at Konya location, They were statistically similar to the mowing value of the first mowing.

#### Fresh Forage Yield

In the study, fresh forage yields were evaluated based on the cumulative total values of three mowings. Whereas the difference between the mean yields of different *L. multiflorum* cultivars at the two locations was also significantly different ( $p < 0.05$ ) in the total of single and double mowings. The difference between the location means in the total of three mowings and the differences between the cultivars when both locations were considered together were significantly different ( $p < 0.05$ , Table 3).

The mean fresh forage yields of different *L. multiflorum* cultivars at Ankara and Konya locations showed yield of 35.583 and 42.470 kg ha<sup>-1</sup>, respectively, and the differences between them was statistically significant ( $p < 0.05$ ). The maximum fresh forage yield was obtained from cv. GB with the value of 39300 kg ha<sup>-1</sup>, while the lowest yield was obtained from cv. Caramba with the value of 29262 kg ha<sup>-1</sup>. In the experiment carried out at Konya location, the maximum fresh forage yield was obtained from cv. Caramba with the value of 44.940 kg ha<sup>-1</sup> and the lowest fresh forage yield was obtained from cv. GB with the value of 38.502 kg ha<sup>-1</sup>. Since both locations were considered together, the difference in fresh yields between cultivars was statistically nonsignificant.

Considering the cumulative fresh forage yields obtained as a result of the first two mowings, the rankings in the two locations changed. The difference between the fresh forage yield means of the cultivars at Ankara and Konya locations showed significantly



Table 3. Mean values of fresh & dry forage yields and crude protein yields (kg ha<sup>-1</sup>) determined for different *L. multiflorum* cultivars at Ankara and Konya locations\*.

Cultivars	One mowing			Two mowings			Three mowings		
	Ankara location	Konya location	Mean	Ankara location	Konya location	Mean	Ankara location	Konya location	Mean*
Fresh forage yield (FFY)									
Trinova	37600	41817	39709	49272	67030	58151	51965	74868	63416 b
Vivaro	35108	42857	38982	50958	70920	60939	56240	88682	72461 ab
Elif	36645	44280	40462	53962	74942	64452	58508	89592	74050 a
Caramba	29262	44940	37101	46582	78178	62380	51425	95928	73676 a
GB	39300	38502	38901	50692	66102	58398	53350	73652	63501 b
Mean*	35583 b	42479 a		50294b	71434a		54298b	84544a	
Dry forage yield (DMY)									
Trinova	10452 a	7279 bc	8866	13248	12640 b	12948	14056	14577 b	14318
Vivaro	8756 ab	8760 abc	8758	12661	15805 a	14233	14013	20009 a	17011
Elif	9333 ab	9356 ab	9345	12906	15893 a	14400	14072	19442 a	16757
Caramba	7232 b	9869 a	8550	10825	17681 a	14253	12046	22154 a	17100
GB	9942 a	6674 c	8308	12606	12101 b	12353	13401	14028 b	13714
Mean*	9143	8388		12444	14824		13518	18042	
Crude protein yield (CPY)									
Trinova	970 a	1163 bc	1067	1382	2098 bc	1739	1519	2426 b	1972
Vivaro	867 ab	1388 ab	1127	1371	2547 a	1959	1599	3171 a	2389
Elif	816 ab	1405 ab	1111	1315	2449 ab	1882	1512	3015 a	2264
Caramba	629 b	1517 a	1071	1089	2861 a	1975	1287	3456 a	2371
GB	885 ab	1036 c	961	1258	1961 c	1609	1390	2273 b	1832
Mean*	834	1302		1283	2383		1462	2869	

\*All values shown by different letters in rows or columns are statistically different within the error limits of  $p < 0.05$  according to Duncan's MRT

different ( $p < 0.05$ ) results in the study. The total yields of the first two mowings of fresh forage yield at the Konya, and Ankara locations were 71.434 and 50.294 kg ha<sup>-1</sup>, respectively. While the maximum yield totals for the first two crops were obtained from cv. Elif at Ankara location with fresh forage yield of 53.962 kg ha<sup>-1</sup> and cv. Caramba with a yield of 78.178 kg ha<sup>-1</sup> at the Konya location, the lowest yields were obtained in these locations with the value of 46.582 kg ha<sup>-1</sup> for cv. Caramba and 66.102 kg ha<sup>-1</sup>, for cv. GB in the same order.

In the third mowing cumulative fresh forage yields, the difference between the location means of the cultivars and the differences between the two locations' mean fresh forage yields of each cultivar were significantly different ( $p < 0.05$ ). Accordingly, the mean forage yield of the cultivars was 84.544 kg ha<sup>-1</sup> and 54.298 kg ha<sup>-1</sup> at Konya and Ankara locations, respectively. Considering both locations together, the maximum fresh forage yield was obtained from cv. Elif with a yield of

74.050 kg ha<sup>-1</sup>, cv. Caramba with a yield of 73.676 kg ha<sup>-1</sup> and cv. Vivaro with a value of 72461 kg ha<sup>-1</sup> in the total of three mowings. Cv. Trinova gave the lowest fresh forage yield with a value of 63416 kg ha<sup>-1</sup>.

Different, but different cultivars can be preferred for both locations due to significant differences among the fresh forage yield of the cultivars between the locations in the first two mowings. Considering three mowings of fresh forage yield together significant differences were noted between locations. Similarly, the cultivars showed statistical differences among themselves when their fresh forage yield was considered cumulatively. Varietal  $\times$  location interactions were not found to be significant for fresh forage yield (Table 3).

#### Dry Forage Yield (DFY)

In the study, the cultivar-location interaction was found significant in the cumulative dry forage yields

of all three mowings, while the difference between the location means and the cultivar means according to the locations was non-significant (Table 3).

Firstly, the maximum dry forage yield was obtained from cv. Trinova with a value of 10.452 kg ha<sup>-1</sup> at the Ankara location, while cv. GB, Elif, and Vivaro were similar. The minimum yield was obtained from cv. Caramba with a value of 7.232 kg ha<sup>-1</sup>. At the Konya location, the maximum dry forage yield was obtained from cv. Caramba with a value of 9.869 kg ha<sup>-1</sup>, unlike Ankara location, cv. Elif and Vivaro lied in the same group. The minimum dry forage yield of this location was obtained from cv. GB with a value of 6.674 kg ha<sup>-1</sup>.

Considering the totals of the two mowings, the difference in dry forage yield of cultivars at Ankara location was not statistically significant, but it indicated significant differences at the Konya location. The maximum dry forage yield at Konya location was obtained from cv. Caramba with a value of 17.681 kg ha<sup>-1</sup>, cv. Elif and Vivaro were statistically similar. At this location, the lowest dry forage yield was obtained from cv. GB with a value of 12.101 kg ha<sup>-1</sup>.

Comparing the totals of the three mowings, it is seen that the statistical difference among the cultivars is only observed at Konya location. Considering the three mowings, the maximum dry forage yield was obtained from the cv. Caramba with a dry forage value of 22.154 kg ha<sup>-1</sup>, while statistically similar dry yields were noted for cv. Vivaro and Elif. At this location province, the lowest yielding cultivar in terms of dry forage was cv. GB with the value of 14.028 kg ha<sup>-1</sup>.

The data obtained on dry forage yields were initially determined as 9.143 kg ha<sup>-1</sup> at Ankara location and 8.388 kg ha<sup>-1</sup> at Konya location. This value was 12.444 kg ha<sup>-1</sup> and 14.824 kg ha<sup>-1</sup> in the total of two mowings, 13.518 kg ha<sup>-1</sup> and 18.040 kg ha<sup>-1</sup> dry yields were obtained in the total of three mowings, respectively.

### Crude Protein Yield (CPY)

Crude protein yields of *L. multiflorum* cultivars was obtained by multiplying the crude protein percentage by the dry forage yield and are given in Table 3. When the table is examined, the various location interaction was found statistically significant according to all three mowing values.

In the first mowing, the maximum crude protein yield was obtained from cv. Trinova with value of 970 kg ha<sup>-1</sup> at Ankara location, while cv. Vivaro, Elif, and GB showed statistically similar values. The lowest crude protein yield of this location was taken from cv. Caramba with the value of 629 kg ha<sup>-1</sup>. With the effect of dry forage yield at Konya location, the maximum crude protein yield was obtained from cv. Caramba with the value of 1.517 kg ha<sup>-1</sup>. This cultivar and cv. Vivaro and Elif were statistically similar. At this location, the minimum crude protein yield was obtained from cv. GB with the value of 1.036 kg ha<sup>-1</sup>.

Considering the total of the two cultivars, the differences between cultivars was found statistically significant only at Konya location in terms of crude protein yields. While the maximum yield was obtained from the cv. Caramba with cpy value of 2.861 kg ha<sup>-1</sup>, at the first mowing, cv. Vivaro with cpy value of 2.861 kg ha<sup>-1</sup> and cv. Caramba with the value of 2.449 kg ha<sup>-1</sup> were statistically similar. The lowest crude protein yield in this location was obtained from cv. GB with the value of 1.961 kg ha<sup>-1</sup>.

Considering the totals of three cultivars, the difference between cultivars in terms of crude protein yields was significantly different at Konya location only. Accordingly, the maximum crude protein yield at this location was obtained from the cv. Caramba with value of 3.456 kg ha<sup>-1</sup>, as in the previous mowings. This cultivar and cv. Vivaro (3171 kg ha<sup>-1</sup>) and Elif (3015 kg ha<sup>-1</sup>) were statistically similar.

## Discussion of Results

The experimental data on yield components are discussed separately in the following lines.

### Plant Height

The experimental results and data of all parameters analyzed singly and collectively at two locations are in line with the findings of Aktar et al. [19] at Şanlıurfa. Çolak and Sancak [14], at Ankara showing that the plant height is stable, and the minor differences could be due to the effect of soil and climatic factors in agreement with Vural and Kokten [20] and Dönmez and Hatipoğlu [21].

### Acid Detergent Fiber

A lower ADF value means higher energy and digestibility. As the ADF percentage increased, the digestibility of the feed decreased, it is known that feeds with low ADF percentages are preferred by ruminants [22]. It could be said that this change in the ADF content of the dry matter, was mainly due to the location or phenotypic effect and was induced by differences in the climates in agreement with Dönmez and Hatipoğlu [21] and Çolak and Sancak [14] who noted effect of changes in ADF due to location effect.

### Neutral Detergent Fiber

If the cumulative findings of all cultivars (46.00% at Ankara and 49.08 at Konya) are compared, the results of the study are lower than Dönmez and Hatipoğlu [21] at Adana (mean of 68.50%) in the Mediterranean Region. It is well known that high temperature effects NDF negatively. Adana which has a warm Mediterranean climate could affect NDF negatively compared to Ankara with a colder climate. The agricultural lands of Bingöl

are generally clayey-loam textured and have neutral or near-neutral reactions, the lime content of the soils varies between low calcareous and medium calcareous with low organic matter [23]. Vural and Kokten [20] noted a higher NDF value (of 59.32%) compared to the value obtained in the present study. This could be due to differences in meteorological conditions along with mild differences in relative humidity at Konya in the current experiment compared to other experiments. Çolak and Sancak [24] noted values of 54.14% to 56.01% at Ankara. These values are lower compared to the values obtained by Özdemir et al. [25] at Bursa.

### Crude Protein Percentage

The 13.9-15.2% values we obtained for the crude protein percentage in *L. multiflorum* cultivars were statistically similar compared to the values obtained by Özdemir et al. [25] 13.20-19.17% at Bursa and Lale and Kökten [15] with the value of 17.58-21.13% at Bingöl, Dönmez and Hatipoğlu [21] in Adana, the two-year means of one-year grasses differ from the values of 10.50-12.00%. The different climatic conditions of the regions, the edaphic characters of soil, the type and dose of fertilizer used, and the variability among the cultivars can be shown as the main reason for the differences in results when compared with current studies.

### Crude Protein Yield

The crude protein yield obtained from the first mowing at Ankara and Konya locations were 834 and 1.302 kg ha<sup>-1</sup>, respectively, Çolak and Sancak [24] determined the mean protein yield in *L. multiflorum* between 361,2-672,7 kg ha<sup>-1</sup> in the study carried out under Ankara ecological conditions. It is quite higher compared to the values obtained between 237.0-677.0 kg ha<sup>-1</sup> by Aktar et al., [19]. The potential reason for the high crude protein yield at Ankara and Konya locations could be carrying out of the experiments under irrigated conditions. The other comparing experiments were carried out under rainfed conditions. The difference could have arisen due to different cultural conditions in these experiments.

### Conclusions

This study reports, the categorization and comparison in growth behavior of different *L. multiflorum* cultivars at hot humid continental climate of Ankara to Cold semi-arid climate conditions of Konya locations of the Central Anatolia in terms of yield and quality using 1, 2, and 3 mowings in a season.

Cold semi-arid climate conditions of Konya compared to hot humid continental climate of Ankara and the plasticity in the behavior of the cultivars affected some parameters. Therefore, Cv. Elif was adjudged the best at Ankara location and cv. Caramba

at the Konya location in terms of fresh and dry matter yield.

The cv. Trinova had the maximum ADF value in mowing and digestibility; however, relative feed value in dry matter contents was low and had the tendency to reduce the quality of harvest after first mowing. -

*L. multiflorum* had higher yield potential with higher crude protein percentage in 2<sup>nd</sup> mowing at Konya compared to the Ankara location when they were compared for yield after the first mowing.

There was a rapid decline in dry forage yield and plant height with each mowing. However, the protein percentage was maximum at the third mowing and did not affect the ADF, NDF values in dry matter contents, and relative feed values.

cv. Trinova could be recommended when only two mowings are desired at Ankara location. Cv. Elif, and Caramba are appropriate if the three mowings are the target at in terms of dry matter yield.

Furthermore, the results indicate Cv. Trinova is recommended when only two mowings are desired at the Ankara location. Cv. Elif, and Caramba are appropriate if the three mowings are the target in terms of dry matter yield.

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### Conflict of Interest

The authors have no conflict of interest among themselves.

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