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Determination of Dry Matter Yields and Quality Characters of Annual Ryegrass (*Lolium multiflorum* Lam.) Genotypes

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A B S T R A C T

This study was carried out to determine yield and quality values of various annual ryegrass varieties genotypes. Five annual ryegrass and four genotypes improved at Aegean Agricultural Research Institute were used. Experiments were conducted at Institute's trial fields in 2020 and 2021. According to data combined over-years, differences between dry matter yields of genotypes were found to be statistically important. Dry matter yields ranged between 1550-1893 kg/da. In terms of quality parameters, differences were also significant. The values were 16.1 - 19.5% for protein contents, 31.7 - 34.7% for ADF and 47.8 - 51.9% for NDF. It was determined that annual ryegrass genotypes showed good performances at Aegean conditions.

1. Introduction

One of the most important problems of animal husbandry in our country is that our animals cannot be fed with quality forages that will reveal their yield potential. Approximately 78.6 million tons of quality forages, which is required by the current 17.1 animal units, cannot be produced in sufficient quantities in our country. The amount of forages produced in field crops is 16 million tons (Anonymous 2020a, 2020b). Despite the increase in the support given to the cultivation of forage crops in recent years, the production of forage crops still has not reached the desired level.

Today, annual grass is among the important forage plant species that can be used as a source of high quality and high yield forages. Annual grass, which belongs to the grass family, adapts to cool and humid climates, and can act as a biennial or short-lived. The optimum temperature for its cultivation is 20-25 °C. It has rapid growth and development and also gives multi cuttings. It is used in the crop rotation as a winter intermediate crop in temperate regions and positively reacts to irrigation and fertilization. It can be planted in a mixture with annual leguminous forage crops (*Trifolium resupinatum* and *Trifolium alexandrinum*). It is utilized as green, dry herbage and silage. It provides forages with high digestibility and energy content (Gençkan,1983; Açıkgöz, 2021).

Although annual grass grows best in fertile, well-drained soils it also adapts well to a wide variety of soil types. It can be grown in heavy, water-retaining acid and alkaline soils (5.0-7.8 pH), and it also has tolerance to moderate salinity (Gençkan, 1983, Ürem, 1985).

The annual grass cultivation area has been increasing in recent years, with a 1.14% share

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(253,297 da) in the total forage crops cultivation area (22,240,273 da) as of 2020, and a 1.67% share (373,275 da) in 2021 (Anonymous, 2021 and 2022). From annual ryegrass, 971,691 tons of green herbage was obtained in 2020, and 1 380,195 tons in 2021.

After, farmers' adoption of annual grass cultivation, the use of varieties developed abroad has become more common. After domestic breeding studies started by Aegean Agricultural Research Institute (AARI; ETAE in Turkish) in 1974, first Efe 82 variety was registered in 1982, and then Elif in 2018 and Zeybek19 in 2019 (Urem, 1985; Anonymous, 2022).

The study was carried out with the aim of determining the yield performances of the genotypes developed by AARI as well as the varieties developed abroad.

2. Materials and Methods

The study was carried out at the Aegean Agricultural Research Institute Menemen/İzmir experimental fields for two years in 2019-2020 and 2020-2021 production seasons. Varieties used in this study: tetraploid Trinova, Alberto, Koga, and Bartigra were improved and registered abroad and then registered in our country; Elif was developed and registered by AARI, and ETAE LM01, ETAE LM02, ETAE LM03, ETAE LM04 genotypes were newly improved. All these genotypes are tetraploid.

The experiment was set up in a randomized block design with four replications. The plots consisted of six rows with a spacing of 25 cm between rows. The plot size is 1.5 m x 5 m = 7.5 m^2. Trials were established on 19.11.2019 and 16.11.2020 by hand. Sowing depth was 2 cm and the sowing norm was 3 kg da^{-1}.

In both years of the experiment, fertilization was given with sowing: 6 kg pure nitrogen and 15 kg da^{-1} phosphorus (P_2O_5) as DAP fertilizer and 20 kg da^{-1} pure potassium (K_2O) as K_2SO_4. Top fertilization was given 10 kg da^{-1} pure nitrogen as CAN fertilizer during the boosting period. After each cutting, top fertilization was done twice with pure 5 kg da^{-1} nitrogen as CAN fertilizer. In the plots, weed control was made by hand, and with a hoe machine between plots when necessary, and water was given in with sprinkler according to the need. Herbicide with active ingredient against broad-leaved weeds was applied to the plot at 20 kg da^{-1}.

Although the cutting time was planned at 20% heading period, there were delays in cutting due to the pandemic in the first year and the plants were harvested at 50% heading period. In the second year, the cuttings were made as planned, when the plants were at 20% heading stage.

In the first year, a single cutting was performed between 21.04.2020 and 08.05.2020. In the second year, two cuttings were made. The first cutting was between 22.04.2021-06.05.2021 and the second cutting was between 10-28.05.2021.

After the plot harvest, the green herbage yield was found by weighing the fresh hay weights (kg da^{-1}). 0.5 kg samples taken randomly from green hay were dried in a drying cabinet at 60 °C for 48 hours and dry matter ratios were determined. Dry matter yield (kg da^{-1}) was calculated by using the dry matter ratio values.

After the dry matter samples were taken to determine dry matter yield, they were ground to pass through a 1 mm sieve (Brabender Ohg Duisburg) for quality analysis. Quality analyzes were made on these samples.

The amount of nitrogen in the dry matter samples was determined by the Dumas method (RapidN Cube, Elementar Analysensysteme GmbH, Germany). Crude protein is calculated by multiplying the determined nitrogen values by 6.25 (AOAC Official Method 990.03 (Anonymous, 2005). Amounts of acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined (separately) with Ankom fiber analyzer (ANKOM Fiber Analyzer, A220) according to the principles specified by Van Soest *et al*. (1991).

Digestible dry matter (DDM) is calculated by ADF% (DM basis), dry matter intake (DMI) by NDF% (DM basis), and relative feed value (RFV) by DDM and DMI values by following formulas (Sheaffer *et al*., 1995).

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

$$\%DMI = \frac{120}{NDF\%}$$

$$RFV = \frac{\%DDM \times \%DMI}{1.29}$$

Evaluation of the data obtained in the study; variance analyzes were performed on the year combination of the data obtained from field trials and laboratory analysis by using the Jump Statistical Package Program (Steel and Torrie, 1980; Yurtsever, 1984)

Mean long term, temperatures and monthly total rainfalls of the years where study was conducted were given at Table 1. First year's rainfall was lower than second year's and long-term rainfall. First and second years mean temperatures were similar to each other and higher than the long-term values (Anonymous, 2019-2021).

The experimental field is in Gediz loam (typic Ustorthent) soil structure (Anonymous, 1971).

Table 1. Climate data of Menemen province 2020-2021

Months	Air temperature (°C)									Rainfall (mm)		
	Mean			Minimum			Maximum					
	2019/20	2020/21	Longterm 1954-2018	2019/20	2020/21	Longterm 1954-2018	2019/20	2020/21	Longterm 1954-2018	2019/20	2020/21	Longterm 1954-2018
November	16.5	13.7	13.0	8.1	4.4	-1.6	26.9	23.0	26.3	59.2	3.0	74.1
December	10.4	12.4	9.6	2.2	4.1	-4.2	20.7	21.4	31.6	65.6	172.8	104.6
January	7.6	10.5	7.8	-1.3	-2.4	-7.2	18.8	22.3	33.6	47.2	164.0	94.9
February	9.9	10.7	8.9	-2.1	-0.7	-5.1	21.3	21.3	39.9	72.8	62.6	73.2
March	12.7	10.4	11.2	0.2	-0.6	-4.0	24.4	21.2	42.8	62.4	129.6	63.3
April	15.2	15.8	15.1	5.8	1.9	-0.9	26.3	30.2	42.1	52.2	33.2	41.0
May	20.7	21.6	20.1	8.5	9.4	3.3	39.7	36.1	44.1	48.6	0.2	27.6
June	23.9	24.9	24.7	12.3	13.0	7.3	34.7	37.6	41.2	34.2	16.8	9.5
Mean	**14.6**	**15.0**	**13.8**	**4.2**	**3.6**	**-1.5**	**26.6**	**26.6**	**37.7**			
Total										**442.2**	**582.2**	**488.2**

3. Results and Discussion

The green herbage and dry matter yield values obtained in the experiment are given in Table 2. In terms of green herbage yield: year, genotype and year*genotype interactions were found to be important as a result of the statistical analysis.

Green herbage yield was higher in the second year compared to the first year. In terms of green herbage yields, Koga variety and developed genotypes except ETAE LM 04 were in the first yield group. Average green herbage yields were between 9247-10045 kg da^{-1}. Although the differences between genotypes are significant, it has been determined that the genotype*year interaction is statistically significant and the differences between the genotypes in terms of green herbage yield depend on the year, as it is explained by Redfearn et al. (2005). ETAE LM 01 genotype, which was in the low yield group in the first year, was in the first yield group in the second year. ETAE LM 03 and ETAE LM 04, which were in the first yield group in the first year, could not take place in the first yield group in the second year. Studies on annual grass have been carried out in many regions of our country and different values have been obtained for green herbage. The green herbage yield values we obtained in this study were higher than 6997.3 and 6645.5 kg da^{-1}determined by Özdemir et al. (2019) in Bursa, and 3377-4458 kg/da determined by Vural and Kökten (2020) in Bingöl.

In terms of dry matter yield, genotype and year *genotype interaction were found to be statistically significant but year was insignificant. Elif variety was in the lowest yield group. Average dry matter yields were between 1550-1893 kg da^{-1}. The materials we developed were in the first yield groups with other genotypes and had high yield values. The differences between the genotypes are significant, it was also determined that the genotype*year interaction was statistically significant. ETAE LM 01 genotype and Koga variety were in the low yield group in the first year, but they rose up to the first yield group in the second year. On the other hand, ETAE LM 02 was in the first yield group in the first year and was in the lower yield group in the second year.

In relation to dry matter yields: Alison et al. (1989) determined 571-416 kg da^{-1}, West et al. (1989) had 691 kg da^{-1}, Yavuz et al. (2017) determined 666-937 kg da^{-1}in Samsun, Vural and Kökten (2020) attained 1044-808 kg da^{-1} in Bingöl, and Kurt and Başaran (2021) obtained 856-1077 kg da^{-1}in Tokat. The dry matter values obtained in our study were higher than those yields.

Crude protein, NDF and ADF ratios (%) of the genotypes used in the experiment are given in Table 3.

Table 2. Green herbage and dry matter yield values of genotypes (kg da^{-1})

Genotypes	Green herbage yield (kg da^{-1})		Mean	Dry matter yield (kg da^{-1})		Mean
	2020	2021		2020	2021	
ETAE LM 01	8331 ik	11506 a	9918 AB	1605 eg	1865 ad	1735 B
ETAE LM 02	9025 fi	10239 be	9632 AC	1824 ad	1689 cf	1757 AB
ETAE LM 03	9481 eg	10609 bd	10045 A	1885 ac	1901 ab	1893 A
ETAE LM 04	9619 ef	9210 fg	9414 BC	1897 ab	1769 af	1833 AB
Trinova	8775 gj	9987 de	9381BC	1766 af	1676 df	1721 B
Alberto	7494 l	11001 ab	9247 C	1704 bf	1764 af	1734 B
Elif	7618 kl	10982 ab	9300 C	1689 cf	1411 g	1550 C
Koga	8225 jl	10785 ac	9505 AC	1589 fg	1943 a	1766 AB
Bartigra	8531 hj	10121 ce	9326 C	1796 ae	1822 ad	1809 AB
Mean	**8567**	**10493**	**9530**	**1751**	**1760**	**1755**
Year			*			NS
Genotype			**			**
Genotype*year			**			**
CV (%)			5.7			8.1
LSD (%5)		1936.5	626.4		503.9	356.3

In terms of crude protein (CP) ratios (%), year, genotype and the interaction of year*genotype were found to be statistically significant. In first year, crude protein ratios of genotypes were significantly lower than the values obtained in the second year. In the second year, rainfall during the growing season was much higher and minimum temperatures were lower (Table 1) than the first year. These promoted the vegetative growth of the plant (Table 2). Besides, the same conditions might have caused the plant to better utilise the nitrogen fertilization. These may explain the relatively higher nitrogen content in the second year. These explanations are supported by the findings of the study of Solomon et al. (2017). Besides, as it is stated in materials and methods section, cutting time for the first year was relatively late compared to the second year. This may also explain the differences between CP ratios of the two years (Redfearn et al, 2002). The highest crude protein ratio was obtained from Bartigra variety with 19.5%, and the lowest crude protein ratio was obtained from Trinova variety with 16.1%. Except for ETAE LM 01, the genotypes were in the high crude protein group. However, it was determined that the genotype*year interaction was statistically significant. While Koga, Bartigra and ETAE LM 02, ETAE LM 03, and ETAE LM 04 genotypes were in the first yield group, ETAE LM 01 genotype was in the second yield group.

The reason for the differences between the crude protein data obtained from this study and the data obtained by other researchers (11.4% by Kavut and Geren (2018); 13.2% by Özdemir et al. (2019); 14.28-17.49% by Kurt and Başaran (2021) can be attributed to the differences between the cutting times, the varieties used, the soil and climate factors of the cultivation areas (Redfearn, 2002; Anonymous, 2023).

Table 3. Crude Protein, NDF and ADF ratios (%) of genotypes

Genotypes	Crude protein (%)			NDF (%)			ADF (%)		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
ETAE LM 01	11.6 fg	23.3 ad	17.4 BC	52.4 bc	43.3 fg	47.9 C	35.2 bd	28.8 gh	32.0 C
ETAE LM 02	13.5 ef	25.0 ac	19.3 AB	57.3 a	42.4 g	49.9 AC	38.0 a	28.1 h	33.0 AC
ETAE LM 03	13.0 ef	25.6 ab	19.3 AB	56.6 a	43.2 fg	49.9 AC	38.0 a	28.8 gh	33.4 AC
ETAE LM 04	14.5 e	21.5 d	18.0 AC	56.0 a	47.7 de	51.8 AB	37.0 ac	32.5 ef	34.7 A
Trinova	9.7 g	22.5 cd	16.1 C	56.0 a	47.9 d	51.9 A	37.6 ab	30.8 fg	34.2 AB
Alberto	10.0 g	22.8 bd	16.4 C	51.4 c	44.1 fg	47.8 C	34.2 de	29.2 gh	31.7 C
Elif	10.0 g	24.9 ac	17.5 BC	51.8 bc	44.4 fg	48.1 C	35.1 cd	29.9 gh	32.5 C
Koga	11.3 fg	25.7 a	18.5 AB	54.6 ab	44.8 eg	49.7 BC	36.4 ad	28.9 gh	32.6 BC
Bartigra	13.2 ef	25.8 a	19.5 A	55.7 a	45.8 df	50.7 AB	36.5 ad	29.7 gh	33.1 AC
Year	11.86 B	24.13A	**	54.64 A	44.84B	**	36.42A	29.63 B	**
Genotype			**			**			**
Genotype*year			*			**			*
CV (%)			9.4			3.6			4.3

LSD (%5)		4.0	3.3	5.3	5.3	5.3		2.1	3.3

In terms of ADF rates (%), year, genotype, year*genotype interaction was found to be statistically significant. ADF values were higher in the first year. The highest ADF ratio was obtained from ETAE LM 04 genotype with 34.7%. The standard cultivars Alberto and Elif and ETAE LM 01 genotype shared the lowest yield group statistically, with the lowest ADF ratios. Because the genotype*year interaction is statistically significant, the differences between genotypes depend on the year. In general, genotypes had high ADF ratios in the first year. While ETAE LM 02 and ETAE LM 03 genotypes were in the first yield group with the highest rate in the first year, they were in the lowest yield group in the second year, while Alberto and Elif varieties with low rates in the first year were in the higher yield group in the following year. In different studies ADF values were determined as 31.63% by Çolak (2015), and between 26.11- 33.30% by Türk et al. (2019).

In terms of NDF values (%), year, genotype, year*genotype interaction was found to be statistically significant. NDF values were higher in the first year. The highest NDF ratio was obtained from Trinova genotype with 51.9%. The lowest NDF value was found in the Alberto genotype with 47.8%. Although the differences between genotypes were significant, it was determined that the genotype*year interaction was statistically significant. In general, genotypes had higher NDF ratios in the first year. While ETAE LM 02 genotype was in the first yield group with the highest rate in the first year, it was in the lowest yield group with the lowest rate in the second year. Alberto and Elif varieties with high NDF ratios in the first year had low NDF ratios in the second year. Other researchers reported the NDF rates on different locations as similar or higher than our results (52.72-58.28% by Kurt and Başaran (2021); 59.67% by Şimşek (2015); 56.5% by Çetin (2017).

As previously mentioned, the plants were harvested at 20% heading period in the second year as planned so the quality was better with high crude protein and low NDF and ADF ratios, whereas plants were harvested at 50% heading in the first year which yielded lower quality values (Table 3). As it is also stated by Redfearn et al. (2002) and Solomon et al., (2017), CP values decreases as the growing season progressed, while NDF and ADF values increases (lowering the nutritive value).

DDM (%) and RFV values are given in Table 4.

In terms of DDM rate (%) year, genotype, year*genotype interaction was found to be statistically significant. In the first year lower DDM rates were obtained. ETAE LM 01 and Trinova genotypes gave the lowest DDM rates. However, although the differences between genotypes were significant, the fact that the genotype*year interaction was statistically significant showed that the differences between the genotypes depended on the year in terms of DDM values. ETAE LM 02 genotype had the lowest rate and took place in the last yield group in the first year and was in the first yield group in the second year. Kara (2016) found DDM as 64.18% in Aydın, which was similar to our results.

Table 4. Digestible dry matter (%) and relative feed value of genotypes in 2020 and 2021

Genotypes	**Digestible dry matter (%)**			**Relative feed value**		
	2020	**2021**	**Mean**	**2020**	**2021**	**Mean**
ETAE LM 01	61.4 eg	66.5 ab	63.9 A	109 df	143 ab	126 A
ETAE LM 02	59.3 h	66.9 a	63.2 AC	96 g	147 a	122 AB
ETAE LM 03	59.3 h	66.5 ab	62.9 AC	98 g	144 ab	121 AB
ETAE LM 04	60.1 fh	63.6 cd	61.8 C	100 ag	124 c	112 C
Trinova (st)	59.6 gh	64.9 bc	62.2 BC	99 fg	126 c	113 C
Alberto (st)	62.3 de	66.1 ab	64.2 A	113 d	140 ab	126 A
Elif (st)	61.6 ef	65.6 ab	63.6 A	110 de	138 ab	124 AB
Koga (st)	60.5 eh	66.4 ab	63.5 AB	103 dg	138 ab	121 AB
Bartigra (st)	60.5 eh	65.8 ab	63.1 AC	101 eg	134 ab	117 BC
Year	**60.52 B	65.8 A		**103.4 B	137.0 A	
Genotype	**			**		
Genotype*year	*			**		
CV (%)			1.8			5.5
LSD (%5)		2.6	2.2		15.4	12.9

In terms of relative feed value (RFV), year, genotype, year*genotype interaction was found to be statistically significant. RFV values were lower in the first year. The highest RFV was obtained from ETAE LM 01 and Alberto genotypes, while the lowest values were obtained from ETAE LM 04 and Trinova genotypes. Although the differences between genotypes are significant, the genotype*year interaction is statistically significant. ETAE LM 02 genotype had the lowest value in the first year and was in the last yield group, and it was in the first yield group in second year. Yavuz *et al*. (2015) determined the RFV between 109.3-122.83.

4. Conclusion

With this study, it has been shown that the varieties developed in our Institute have similar or superior yield and quality characteristics compared to standard varieties used. As a result of this study two genotypes ETAE LM02 and ETAE LM 04 are registered as Efe 2023 and Fırtına23, respectively. The registration process for other two genotypes (namely, ETAE LM 01 and ETAE LM 03) are still continuing. According to results of this study, annual ryegrass maintains high forage yield with high quality and can be used as a intercrop in winters at coastal and other places with mild climates in order to increase forage production. Therefore, as it is also stated by Solomon et al.,2017 (concluded from Lippke and Ellis,1997), they can be used as intercrops.

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