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Silage Quality of Some Italian Ryegrass Varieties Grown in Sivas Ecological Conditions

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A R T I C L E I N F O

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A B S T R A C T

This research was carried out to determine the silage characters of some Italian ryegrass varieties. 21 Italian ryegrass varieties (Master, Quickston, Big Boss, Koga, Venüs, Braulio, Jivet, Medoacus, Excellent, Tornado, İlkadım, Caramba, Kartetra, Efe-82, Trinova, Hellen, Devis, Vallivert, Teanna, Rambo, Zeybek-19) were used as materials. The trial was conducted in the 2022-2023 growing season on land belonging to the Agricultural Ar&Ge Center of Sivas Science and Technology University, Faculty of Agricultural Sciences and Technology. Harvesting for silage making was done when the grains on the ears reached the milking stage, silage samples were placed in 2 kg plastic vacuum bags, and the bags were opened after 60 days for analysis. As a result of the analysis, it was determined that the acid detergent fiber (ADF) rates in silage varied between 31.09-36.74%, neutral detergent fiber (NDF) rates varied between 52.56-61.75%, crude protein rates varied between 9.76-12.34%, crude ash rates varied between 8.23-12.01%, dry matter rates varied between 21.27-29.90%, pH values varied between 4.46-5.90, dry matter digestibility rates varied between 60.28-64.68%, dry matter intake rates varied between 1.95-2.28% and the relative feed value varied between 90.9-113.6, depending on the Italian ryegrass varieties. Among the Italian ryegrass varieties examined in the research, Koga and Vallivert varieties, which have low acid detergent fiber and neutral detergent fiber rates, high dry matter digestibility and dry matter intake rates, and relative feed value, stand out and it is suggested that these varieties can be grown in Sivas and similar ecologies for silage purposes.

1. Introduction

The fodder crop known as Italian ryegrass (*Lolium multiflorum* Lam.) holds great worldwide importance. According to Parvin et al. (2010), it is presently widely distributed over temperate regions of the world and grown in Europe, America, and Asia. One of the most important and common forages for dairy cows in temperate areas is Italian ryegrass (Lv et al., 2021).

Its high forage production, nutritional value, digestibility, and superior ensiling properties make it a frequent fodder for grazing ruminants. Its high amounts of soluble and degradable nitrogen and carbohydrates are particularly noteworthy (Stergiadis et al., 2015). Studying these changes is essential to enhancing the quality of silage since frequent changes in the microbial population take place during the aerobic and anaerobic stages of fermentation (You et al., 2022).

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Ensiling is a common procedure to preserve the forage's nutritional quality and provide a year-round supply of feed to suit the animals' production needs (Souza et al., 2022). The quality of the silage's fermentation is also influenced by the stage of plant development during harvest. Due to the fact that variables influencing ensilability, such water-soluble carbohydrates (Longland, 2012), dry matter (Xue et al., 2018), and buffering capacity (Zhao et al., 2022), vary as plants develop. It is commonly recognized that the process of natural fermentation, in which the epiphytic lactic acid bacteria transform carbohydrates into lactic acid under anaerobic circumstances, provides the basis for the preservation of fodder crops by ensiling. The pH drops as a result, preserving the silage. Because there is still air in the silage during the early stages of ensiling, plant respiration and aerobic microbial activity can occur, which results in the loss of both nutritional content and fermentation substrates. The silage is stabilized and the grass may be kept for a long time when lactic acid bacteria lower pH under anaerobic conditions. Effective silage production depends on the pace and effectiveness of acid generation during the first stage of fermentation by the epiphytic lactic acid bacteria (Weinberg et al., 1988). The quality of the silage is also significantly influenced by the early fermentation. The year-round livestock output and the seasonal imbalance in feed availability can be reconciled with the aid of Italian ryegrass silage (Wright et al., 2000).

Because of Italian ryegrass high nutritional content, it is a crucial seasonal feed for ruminants (Fluck et al., 2018). However, because growth stage is the primary element determining the nutrition and digestibility of fodder, the efficiency with which Italian ryegrass is utilized at harvest is highly dependent on it (Valente et al., 2000). However, the harvest stage of forage cannot always be carried out in accordance with the production schedules when considering the practice conditions, such as rainy or the lack of harvest equipment (Comino et al., 2014). The aim of this study was to determine silage quality of some Italian ryegrass varieties grown in Sivas ecological conditions.

2. Materials and Methods

Twenty-one recognized Italian ryegrass varieties (Master, Quickston, Big Boss, Koga, Venüs, Braulio, Jivet, Medoacus, Excellent, Tornado, İlkadım, Caramba, Kartetra, Efe-82, Trinova, Hellen, Devis, Vallivert, Teanna, Rambo, Zeybek-19) were employed as plant material in the study. The experiment was set up in the 2022 2023 growing season at Sivas Science and Technology University, Faculty of Agricultural Sciences and Technology, Agricultural Ar&Ge Center trial area, according to the randomized block trial design, with three replications. The experiment's parcel area was designed to have six rows and a length of 5 meters. Using a row spacing of 20 cm and 4 kg. of seeds per decare, the seeds were sown during the first week of October. The trial site was fertilized with DAP at a rate of 4 kg nitrogen (N) and 10 kg phosphorus (P_2O_5) per decare at the time of planting (Lale, 2020). Six kg of nitrogen per decare were used for top fertilization once the plants were about thirty cm tall.

The climate of the province of Sivas is continental, with hot, dry summers and cold, snowy winters. Key climatic variables for the study period, such as humidity, precipitation, and temperature, are shown in Table 1. The average temperature that was observed was as low as -3.6 ^{0}C in February and as high as 17.3 ^{0}C in June. The total amount of precipitation between October 2022 and June 2023 was 421.2 mm, above the long-term average of 326.6 mm. The average relative humidity value varied month to month from 62.8% to 95.3%, which is higher than the long-term average of 64.0% (Anonymous, 2024a).

Table 1. Precipitation, temperature and relative humidity values of the period of the experiment

Months	Total Precipitation (mm)		Average Temperature (°C)		Average Relative humidity (%)	
	2022-2023	Long Term	2022-2023	Long Term	2022-2023	Long Term
October	16.6	19.0	11.6	12.5	62.8	57.6
November	39.6	32.3	6.6	6.1	74.2	69.9
December	23.8	29.8	3.0	2.7	86.1	79.8
January	7.2	46.1	0.9	-2.0	87.3	74.0
February	43.8	35.4	-3.6	0.6	92.4	71.2
March	107.6	44.2	6.4	2.5	93.0	64.7
April	74.8	23.2	9.1	11.1	92.8	50.0
May	56.4	18.9	13.0	13.9	93.6	53.8
June	51.4	77.7	17.3	18.6	95.3	55.2
Total/Ave.	**421.2**	**326.6**	**7.1**	**7.3**	**86.4**	**64.0**

The chemical and physical properties of the testing location are listed in Table 2. The pH of the silty clay loam soil in the Sivas area was 7.28. It was also noteworthy for having low levels of organic matter (1.7%), phosphorus (P_2O_5) (3.40 kg/da), potassium (K_2O) (93.59 kg/da), lime (19.6%), and salt (0.33%)(Anonymous, 2024b). During the study, there was no groundwater problem and the land was sufficiently drained.

Table 2. Physical and chemical properties of the soil of the trial site

Depth	Texture	pH	Lime (% $CaCO_3$)	Salinity (%)	P_2O_5 (kg/da)	K_2O (kg/da)	Organic matter (%)
0-30 cm	Silty clay loam	7.28	19.6	0.33	3.40	93.59	1.7

The plants harvested from each parcel were chopped into pieces of 0.5-1 cm with a branch shredding machine and placed in 2 kg plastic vacuum bags. The bags were then de-aired, tightly closed and stored in a dark place (24±2 ^{0}C). At the end of the 60th day, the silage bags were opened and a 30-g sample was taken from each bag. The samples were mixed with 270 mL of distilled water and pH values were measured. Additionally, 250 g of silage samples taken from each bag were dried in an oven at 70 ^{0}C until they reached a constant weight and dry matter ratios were determined. pH values in silages were measured with a digital pH meter (Ergün ve ark., 2013). Dry silage samples of the Italian ryegrass varieties were ground in a mill and passed through 1 mm for chemical analysis. Crude ash ratio of Italian ryegrass silages was determined by burning at 550 ^{0}C for 8 hours (Anonymous, 1990). Crude protein analyses were performed by the methods specified in Anonymous (2003). The ADF and NDF constituting the cell wall were performed by the method specified in Van Soest (1963) and Van Soest and Wine (1967). Relative feed value (RFV), dry matter digestibility (DMD) and dry matter intake (DMI) of Italian ryegrass samples were calculated according to the formulas (Morrison, 2003).

DMD % = 88.9 - (0.779 x ADF %); DMI % = 120 / NDF %; RFV = (DDM % x DMI %) /1.29.

The analysis of the data obtained silages of Italian ryegrass varieties was made in the Jump-Pro13 statistical package program and the differences between the averages were compared according to the Tukey test. Correlation analysis and color map were made in Jump-Pro13.

3. Results and Discussion

Acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), crude ash (CA), dry matter (DM), dry matter digestibility (DMD) and dry matter intake (DMI) ratios and relative feed value (RFV) and pH values determined in the samples of Italian ryegrass varieties grown in Sivas ecological conditions were found to be statistically significant at the 1% level (Table 3).

The ADF and NDF ratios of the silage of Italian ryegrass varieties varied between 31.09-36.74% and 52.56-61.75%, respectively. While the highest ADF and NDF ratios were obtained from Braulio variety; the lowest ADF rate was found in Koga variety, and the lowest NDF rate was found in Vallivert variety. In a study investigating the effects of the epiphytic microbiota and chemical composition of Italian ryegrass harvested at different growth stages on silage fermentation, it was reported that ADF and NDF values varied between 322-348 g/kg DM and 524-570 g/kg DM, respectively (Yin et al., 2022), while in a study investigating the effects of different nitrogen doses and varieties on the fermentation quality and nutritional value of Italian ryegrass (*Lolium multiflorum* Lam.) silages, it was reported that ADF and NDF values varied between 36.0-38.0% and 61.2-65.4% DM, respectively (Ertekin et al., 2022). In a study investigating the effects of different nitrogen doses and varieties on some nutritional values of annual grass (*Lolium multiflorum* var. *westerwoldicum*) silage, it was reported that ADF and NDF values varied between 27.7-42.47% and 45.34-65.41% DM, respectively (Orou Ouennon Assouma and Çelen, 2022). On the other hand, in a study investigating the effects of growth stage on the fermentation quality, microbial community and metabolomic properties of Italian ryegrass (*Lolium multiflorum* Lam.) silage, it was reported that ADF and NDF values varied between 28.21-28.40% DM and 50.86-54.28% DM, respectively (Fu et al., 2023).

The crude protein and crude ash rates of the silages of Italian ryegrass varieties varied between 9.76-12.34% and 8.23-12.01%, respectively. The high crude protein rate of the silages of Italian ryegrass varieties was obtained in Rambo variety, followed by Efe-82, Master, Kartetra and Excellent varieties, which are statistically in the same group. The highest crude ash rates were found in Koga variety. On the other hand, the lowest crude protein and crude ash rates in the silages of Italian ryegrass varieties were obtained in Vallivert and Trinova varieties, respectively. The crude protein and crude ash rates were obtained as 3.38-10.49% and 8.23-13.18%, respectively, in the silage of *Lolium multiflorum* var. *westerwoldicum* (Orou Ouennon Assouma and Çelen, 2022), as 8.5-14.5% and 11.7-13.1%, respectively, in the *Lolium multiflorum* Lam. (Ertekin et al., 2022). On the other hand,

crude protein rates were obtained as 58.8-62.7 g/kg TN in the silage of Italian ryegrass harvested at different growth stages (Yin et al., 2022), as 19.61-23.54% of DM in the *Lolium multiflorum* Lam. (Fu et al., 2023).

Table 3. Average values of silage quality characteristic of Italian ryegrass varieties

Varieties	ADF (%)	NDF (%)	CP (%)	CA (%)	DM (%)	pH	DMD (%)	DMI (%)	RFV
Big boss	36.21^{ab}	60.74^{ab}	10.27^{ef}	8.44^{g}	26.73^{d-g}	5.11^{d-f}	60.69^{gh}	1.98^{gh}	93.0$^{h-ı}$
Braulio	36.74^{a}	61.75^{a}	10.40^{d-f}	10.68^{bc}	29.90^{a}	5.90^{a}	60.28^{h}	1.95^{h}	90.9^{ı}
Caramba	35.55^{a-c}	60.04^{a-d}	10.97^{c-e}	8.50^{g}	24.53^{j}	5.21^{de}	61.20^{f-h}	2.00^{e-h}	94.8$^{g-ı}$
Devis	33.70^{d-g}	57.67^{b-f}	10.51^{d-f}	8.83^{e-g}	27.53^{cd}	5.14^{de}	62.65^{b-e}	2.09^{c-g}	101.3^{d-g}
Efe 82	33.09^{fg}	56.06^{e-h}	12.17^{ab}	9.53^{d-f}	21.27^{l}	5.13^{de}	63.12^{bc}	2.14^{cd}	104.8^{c-e}
Excellent	32.50^{gh}	54.68$^{f-ı}$	12.04^{ab}	8.42^{g}	24.53^{j}	5.67^{b}	63.59^{ab}	2.20^{a-c}	108.2^{a-c}
Hellen	33.66^{d-g}	57.88^{b-e}	11.24^{b-e}	8.86^{e-g}	26.90^{de}	4.95^{f-h}	62.68^{b-e}	2.07^{d-g}	100.8^{d-g}
İlkadım	32.46^{gh}	55.47$^{e-ı}$	11.17^{b-e}	8.75^{e-g}	25.63^{f-j}	4.46^{ı}	63.61^{ab}	2.16^{b-d}	106.7^{b-d}
Jivet	33.07^{fg}	57.16^{c-f}	11.34^{a-d}	10.66^{bc}	25.07^{ıj}	5.15^{de}	63.14^{bc}	2.10^{c-f}	102.8^{c-f}
Kartetra	34.44^{b-f}	60.15^{a-c}	12.12^{ab}	8.42^{g}	29.53^{ab}	5.27^{d}	62.07^{c-g}	2.00^{f-h}	96.0$^{g-ı}$
Koga	31.09^{h}	53.03^{hı}	11.30^{b-e}	12.01^{a}	25.33^{h-j}	5.67^{bc}	64.68^{a}	2.26^{ab}	113.6^{a}
Master	33.52^{d-g}	57.94^{b-e}	12.14^{ab}	9.69^{c-e}	25.57^{g-j}	5.50^{c}	62.79^{b-e}	2.07^{d-g}	100.9^{d-g}
Medoacus	33.15^{e-g}	56.05^{e-h}	11.63^{a-c}	8.80^{e-g}	26.53^{d-h}	5.55^{bc}	63.07^{b-d}	2.14^{cd}	104.7^{c-e}
Quickstan	35.19^{a-d}	60.06^{a-d}	11.92^{a-c}	11.36^{ab}	27.17^{de}	5.62^{bc}	61.49^{e-h}	2.01^{e-h}	95.6$^{g-ı}$
Rambo	34.73^{b-f}	59.82^{a-d}	12.34^{a}	8.89^{e-g}	26.03$^{e-ı}$	5.53^{bc}	61.85^{c-g}	2.01^{e-h}	96.2$^{f-ı}$
Teanna	32.17^{gh}	53.31$^{g-ı}$	11.67^{a-c}	11.00^{ab}	25.17^{ıj}	5.07^{e-g}	63.84^{ab}	2.25^{ab}	111.5^{ab}
Tornado	34.46^{b-f}	58.30^{b-e}	10.58^{d-f}	8.55^{fg}	23.03^{k}	5.64^{bc}	62.06^{c-g}	2.07^{d-g}	99.6^{e-h}
Trinova	33.12^{e-g}	56.37^{e-g}	11.63^{a-c}	8.23^{g}	26.83^{d-f}	5.09^{e-g}	63.10^{b-d}	2.13^{cd}	104.3^{c-e}
Vallivert	32.45^{gh}	52.56^{ı}	9.76^{f}	9.62^{de}	26.87^{de}	4.85^{h}	63.62^{ab}	2.28^{a}	112.6^{ab}
Venüs	33.93^{c-g}	57.31^{c-f}	10.29^{ef}	8.80^{e-g}	27.27^{d}	4.88^{h}	62.47^{b-f}	2.09^{c-f}	101.4^{d-g}
Zeybek-19	34.90^{b-e}	56.98^{d-f}	10.37^{d-f}	10.43^{b-d}	28.57^{bc}	4.92^{gh}	61.71^{d-g}	2.11^{c-e}	100.9^{d-g}
Average	33.82 **	57.30 **	11.25**	9.45 **	26.19**	5.25**	62.56**	2.10**	101.9**
CV	3.22	3.27	5.59	6.52	2.83	1.94	1.36	3.21	3.96

**; significant at the P≤0.01 level. There is no statistical difference between the averages shown with the same letter.

The dry matter ratio and pH value of the silages of Italian ryegrass varieties varied between 21.27-29.90% and 4.46-5.90, respectively. While the highest dry matter rate and pH value of the silages was obtained in Braulio variety, the low dry matter rate and pH value were obtained in Braulio and İlkadım varieties, respectively. The dry matter rate and pH value were obtained as 19.3-26.2% and 5.90-4.46, respectively, in the silage of Italian ryegrass in response to nitrogen, cultivar and cutting rank (Ertekin et al., 2022), as 206-374 g/kg FW and 3.49-5.22, respectively, in the silage of Italian ryegrass harvested at different growth stages (Yin et al., 2022), as 30.86-35.23% and 4.67-6.18, respectively, in the *Lolium multiflorum* Lam. (Fu et al., 2023). On the other hand, the dry matter rate was obtained as 37.66-58.66% in silages of some annual ryegrass varieties applied with different nitrogen doses (Orou Ouennon Assouma and Çelen, 2022).

The DMD and DMI ratios and RFV values of the silages of Italian ryegrass varieties differed statistically by 1% among varieties and varied between 60.28-64.68%, 1.95-2.28% and 90.9-113.55, respectively. While the lowest DMD, DMI and RFV values of the silages was obtained in Braulio variety, the highest DMD and RFV value were obtained in Koga variety and the highest DMI rates were obtained in Vallivert variety. The DMD and DMI rates and RFV value in the silage of Italian ryegrass in response to nitrogen, cultivar and cutting rank varied between 55.9-59.0%, 1.8-.19% and 78.1-88.2, respectively (Ertekin et al., 2022). On the other hand, it has been reported that the relative feed value in silages of some annual ryegrass varieties applied with different nitrogen doses varies between 79.4-138.2 (Orou Ouennon Assouma and Çelen, 2022).

Principal Component (PC) biplot analysis was performed to strongly demonstrate the

relationships between the examined traits in Italian ryegrass silage samples. According to the study results, PCA explained 69.21% of the total variation, while PC1 showed 53.45% and PC2 showed 15.76% on the biplot (Figure 1). It was determined that there was a positive relationship between CP and Ph, CA, DMD, RFV and DMI, while ADF, NDF and DM formed a separate group and had a positive relationship between each other. It was determined that there was a negative relationship between these two groups.

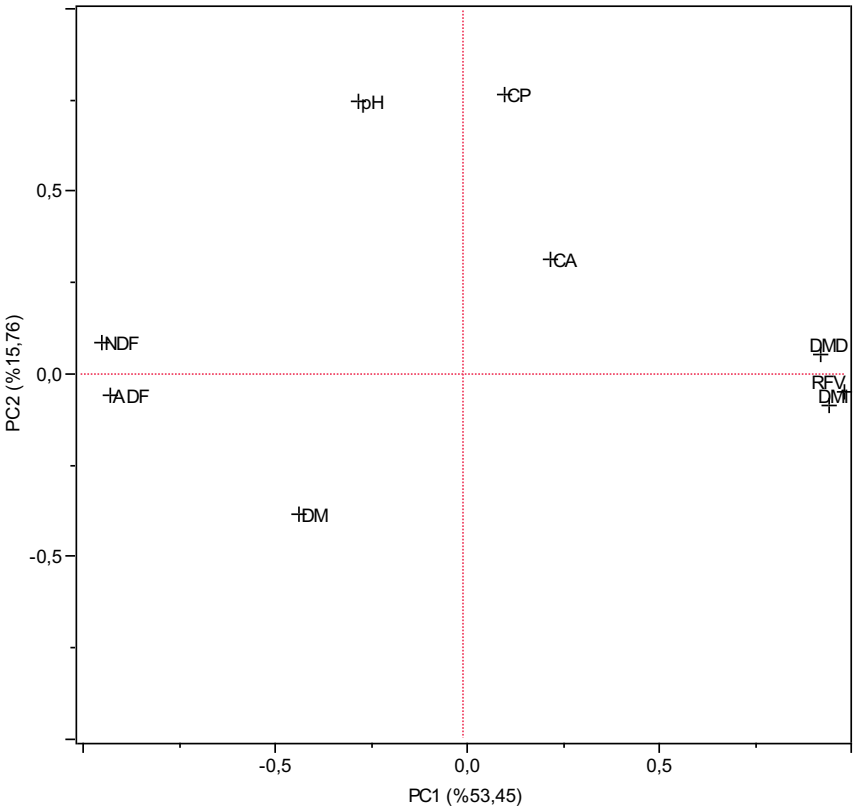

Figure 1. Principal component biplot analysis of the relationships between the examined features

4. Conclusions

This study was conducted to provide information on determining the silage quality of Italian ryegrass varieties grown in Sivas ecological conditions. Italian ryegrass varieties showed significant differences in terms of silage quality. This study depicted that (i) Koga variety was the most favorable varieties according to crude ash rate, (ii) Rambo, Efe-82, Master, Kartetra and Excellent varieties were the best for crude protein rates, (iii) İlkadım variety was the most stable varieties according to pH value (iv) Koga and Vallivert varieties showed the lowest ADF and NDF rates (v) Koga and Vallivert varieties were the best for DMD, DMI and RFV values.

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