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GRAIN YIELD AND NUTRITIONAL QUALITY OF DIFFERENT RYE GENOTYPES

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ABSTRACT

Rye (*Secale cereale* L.) has a high tolerance to cold, drought, diseases and pests. Besides, rye improves soil structure, builds organic matter and helps protect again water and wind erosion. The aim of this study was to determine the grain yield and quality of rye as feed in Central Anatolian conditions. For this purpose, nine landrace and one variety (Aslım-95) of rye and one variety of triticale (Karma-2000) were investigated for grain yield, crude protein content, acid detergent fiber (ADF), neutral detergent fiber (NDF), potassium, phosphorus, calcium, magnesium, total phenolic, total flavonoid, DPPH free radical scavenging activity and condensed tannin content. Experiments were carried out in Yozgat ecological conditions in 2018-2019 and 2019-2020 growing seasons in a randomized block design with three replications. There were significant ($p<0.01$) differences between genotypes and years in terms of grain yield and all the nutritional quality traits. According to the quality traits, it was determined that some landraces have better performance than the variety of rye and triticale. As result, it was determined that the landraces have the potential to be used as a genetic resource in breeding studies in terms of yield and quality traits for feed type rye.

Keywords: Grain yield, genotypes, nutrition, rye.

INTRODUCTION

The cereals, low-input crops, are important for extensive small ruminant production at dry agricultural systems. Winter cereals at the early vegetative stage offer high nutritive value forage for ruminants while they provide live weight gains with those of kernels (Coblentz and Walgenbach, 2010).

Cereal grains commonly used to feed livestock include oats, corn, wheat, barley, triticale, and rye. They are a concentrated source of energy, with much of that energy stored as starch. Besides, cereal grains provide energy, protein, vitamins, minerals, fiber and secondary metabolites to the animal diet. These compounds vary between species and varieties of cereals (Kan, 2015; Duddy et al., 2022).

Rye is highly tolerant to cold, drought, diseases, and pests, and it can grow in all kinds of soil (marginal lands) compared to the other winter cereals. It can use water well and does not require much maintenance due to its strong root system. Lutheria et al. (2012) reported that it protects and improves the soil structure. Rye gives a higher yield than other grains on unproductive soils that are not suitable for wheat and barley cultivation (Kumbasaroglu and Dagdemir, 2010). In addition, rye can easily grow in marginal areas as its water demand is low and its adaptation limits are wide. Although cereal grains have many structural similarities, they can differ in the relative proportion of their chemical composition. In addition, yield and quality characteristics may vary due to ecological and regional differences between species and varieties. For this reasons, the objective of the current study was to determine the yield and quality traits of different rye genotypes at Yozgat ecological conditions in the 2018-2019 and 2019-2020 growing seasons.

MATERIALS AND METHODS

Plant material

In this study, 10 rye genotypes (consisting of 'Aslım-95' variety and nine Turkish origin landrace) and one triticale variety (Karma-2000) were used as plant material (Table 1).

Table 1. Origins of the rye genotypes used in the study

Plant material	Origin
Akdag-1	Eynelli village/Akdagmadeni district/Yozgat
Akdag-2	Uckaraagac village/Akdagmadeni district/Yozgat
Bayburt	University of Bozok, Faculty of Agriculture
Cekerek	Cemaloglu village/Cekerek district/Yozgat
Kadisehri	Ovacık Village/Kadisehri district/Yozgat
Sorgun-1	Gulsehri town/Sorgun district/Yozgat
Sorgun-2	Arapli town/ Sorgun district/Yozgat
Yozgat-1	University of Bozok, Faculty of Agriculture
Yozgat-2	University of Bozok, Faculty of Agriculture
Aslim-95	Variety of rye
Karma-2000	Variety of triticale

Experimental design

The experiment was conducted during the 2018-2019 and 2019-2020 winter growing seasons at the Osmaniye village, Sorgun district of Yozgat province-Turkey. Table 2 shows the meteorological data of the experiment area during the growing season (September – June), including monthly average temperature, monthly sum of precipitation and average moisture. The total precipitation was 344.9 mm at the long-term, and it was 393.6 mm in 2018-2019 and 365.8 mm in 2019-2020 seasons (Table 2).

Table 2. Meteorological data of experiment area in the long term and studied years*

Months	Temperature (°C)			Precipitation (mm)			Moisture (%)		
	LT**	2018-19	2019-20	LT**	2018-19	2019-20	LT**	2018-19	2019-20
September	12.3	12.8	14.2	22.9	36.8	7.0	65.9	65.6	58.3
October	5.9	6.8	7.0	29.9	17.0	21.8	72.5	70.2	59.6
December	-0.7	2.0	2.9	33.6	81.6	49.2	77.3	82.6	79.7
January	-1.0	-0.8	-0.5	59.5	70.2	25.0	77.5	80.3	75.8
February	2.8	2.7	0.9	21.9	30.2	73.6	75.8	73.2	75.0
March	6.0	4.3	6.3	47.3	15.2	24.6	71.0	62.0	65.7
April	9.8	8.3	8.5	23.8	26.2	32.2	66.6	66.6	59.6
May	14.7	16.0	14.5	47.9	22.2	39.0	64.2	56.7	58.1
June	18.7	20.0	18.1	50.1	79.8	89.6	60.5	63.0	58.5
July	21.1	19.5	22.1	8.0	14.4	3.8	56.8	56.2	52.6
Total	-	-	-	344.9	393.6	365.8		-	
Average	8.96	9.16	9.40	-	-		68.81	67.64	65.29

*: Turkish State Meterogical Service, **: Long-term

The study was carried out in two different fields and the soil properties of the experiment fields taken from 30 cm depth were loam type with pH of 8.14-7.98 and 7.12-18.51% $CaCO_3$, 88.9-105.4 kg ha^{-1} phosphorus, and 3.49-2.45% organic matter. Experiment was conducted according to Randomized Complete Block Design with three replications. The plots were formed in 18 rows with a length of 8 m and a row spacing of 13 cm. The 240 kg seeds were used per hectare. The 240 kg ha^{-1} DAP (18-46%) was applied as basal fertilizer and then the 120 kg ha^{-1} urea fertilizer (46% N) was applied as a top fertilizer. In the 2018/2019 vegetation season, the harvest was done on 13 July, and in the second year (2019/20) on 25 July, in the optimal time. After harvest, the grain was blended and prepared for chemical analysis.

Chemical analyses

The crude protein ratio (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), potassium (K), phosphorus (P), calcium (C) and magnesium (Mg) content of grain samples were determined by using Near Reflectance Spectroscopy (NIRS, 'Foss 6500') with software package program 'IC-0904FE'.

The total phenolic content (TP) of samples was determined according the modified method described by Singleton et al. (1999). Samples (200 µL) were mixed with 200 µL of the Folin-Ciocalteu reagent and 200 µL of sodium carbonate (Na_2CO_3) solution. Then, samples are incubated in the dark, for 120 min at room temperature. The absorbance of extracts were read at 760 nm with a Peak Instruments (E-1000V-USA) of spectrophotometer. The total phenolic contents were expressed as mg equivalents of gallic acid (GAE) g^{-1} dry weight (DW) according to the equation obtained from the standard gallic acid graph and calculated from the calibration curve (R^2= 0.9994).

The total flavonoid content (TF) was carried out following the method described by Arvouet-Grand et al. (1994) with some modifications. Each sample (200 µL) was mixed with 100 µL of aluminum nitrate (10%) and 100 µL of potassium acetate (1 M). The total volume of the solution was adjusted to 5mL with ethanol. The absorbance was read at a Peak Instruments (E-1000V-USA) of spectrophotometer value of 417 nm after 40 min incubation at room temperature in dark conditions. Total flavonoid content was expressed as mg equivalents of quercetin (QE) g^{-1} DW according to the equation obtained from the standard quercetin graph and calculated from the calibration curve (R^2= 0.9994).

The measurement of the DPPH radical scavenging activity was performed according to methodology described by Gezer et al. (2006). 4 mg DPPH was added to 100 mL of the solvent (methanol/ethanol) to prepare the concentration. The extracts dissolved in methanol and ethanol was used. The 8 mg mL^{-1} extract solutions were prepared as the main stock, and the dilutions were obtained at different concentrations (100, 200, 400, 600, 800, and 1000 µg mL^{-1}) from this stock. 200 µL of extract solutions in different concentrations were added into 3.2 mL of DPPH solution. The solvent amounts in each test tube were set to be 200 µL of ethanol and 3.2 mL methanol. The absorbance at 517 nm was recorded after 30 min of incubation at room temperature in dark using Peak Instruments (E-1000V-USA) of spectrophotometer.

The condensed tannin analysis was identified according to Bate-Smith (1975). A 6 ml of tannin solution was added to 0.01 g of ground sample then placed in a tube and mixed on a vortex. The tubes were tightly capped and kept at 100°C for 1 hour, and the samples were allowed to cool. Then, they were read at a spectrophotometer at the absorbance value of 550 nm. Condensed tannins (CT) were calculated by the following formula: Absorbance (550 nm x 156.5 x dilution factor) / Dry weight (%).

Statistical analyses

Analysis of variance (ANOVA) was performed by using SPSS 22.0 package program and Multiple comparisons were performed using the LSD test at the 0.05 probability level according to Steel and Torrie (1980).

RESULTS AND DISCUSSIONS

Grain yield and crude protein ratio of rye genotypes and triticale were given in Table 3. There were significant ($p<0.01$) differences between investigated genotypes and years in terms of grain yield and crude protein ratio (Table 3).

Table 3. Total grain yield and crude protein content of genotypes

Genotypes	Grain yield (t ha^{-1})			Crude protein ratio (%)		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	2.26 b	2.03 b	2.15 c	13.73 bc	13.54 abc	13.64 bc
Akdag-2	1.95 cd	1.84 cde	1.90 e	13.57 c	13.33 de	13.45 de
Bayburt	1.71 e	1.77 de	1.74 f	13.29 de	13.21 e	13.25 fg
Cekerek	2.07 c	1.87 cd	1.97 de	13.78 ab	13.63 ab	13.71 ab
Kadisehri	2.04 c	1.89 c	1.97 de	13.72 bc	13.46 bcd	13.59 bc
Sorgun-1	2.36 b	2.14 a	2.25 b	13.68 bc	13.44 cd	13.56 cd
Sorgun-2	2.74 a	2.16 a	2.45 a	13.63 bc	13.40 cd	13.52 cd
Yozgat-1	1.82 de	1.75 e	1.79 f	13.20 e	13.20 e	13.20 g
Yozgat-2	1.73 e	1.76 de	1.75 f	13.40 d	13.31 de	13.36 ef
Aslim-95	1.97 cd	2.03 b	2.00 d	12.87 f	13.67 a	13.27 fg
Karma-2000	1.44 f	1.37 f	1.40 g	13.94 a	13.69 a	13.82 a
Mean	***2.01 A*****	***1.87 B*****		***13.53 A*****	***13.44 B*****	
LSD	***15.43***	***10.09***	***8.932***	***0.178***	***0.194***	***0.127***

**Significant differences at $p< 0.01$; Aslim-95: Variety of rye; Karma-2000: Variety of triticale.

The highest grain yield was determined in Sorgun-2 landrace of rye (2.74, 2.16, and 2.45 t ha^{-1}) while the lowest was in triticale (1.44, 1.37 and 1.40 t ha^{-1}). These results show that rye landraces positively respond to Yozgat ecological conditions in terms of grain yield. On the other hand, grain yield was significantly affected by the year and was higher in the first year, which can be caused by higher sum of precipitation in the first year. Kabak and Akcura (2017) found that the grain yield of different rye genotypes was ranged from 0.93 t ha^{-1} to 3.41 t ha^{-1}.

Kun (1996) reported that the protein ratio of triticale can be higher compared to other cool season cereals. Accordingly, the highest crude protein was determined in triticale (13.82%) and landrace of Cekerek (13.71%) in average for both vegetation seasons. Variety Aslim-95 had the lower protein content in relation to protein content measured in landraces in terms of protein ratio. This indicates that the landraces are promising in terms of crude protein content. Bagci et al. (2019) founded that the crude protein content of different rye grains was ranged from 9.52% to 13.25%. Previous studies indicated that the crude protein content of rye and triticale ranged between 9.2-14.0% and 12.3-14.8%, respectively (Mut and Erbas Kose, 2018; Linina et al., 2019). Differences can be due to several factors such as cereal type, climatic conditions, location and structure of grains.

The ADF and NDF ratios of the genotypes were given in Table 4. Accordingly, the effect of genotypes on ADF and NDF ratio was significant ($p<0.01$) on average for both seasons and in each vegetation season. ADF and NDF values determine the digestibility of feed (Raffrenato et al., 2017; Mut et al., 2022). The ADF is the digestibility of the feed and the energy intake of the animal, while the NDF is the features that directly affect the feed intake of the animal

(Erbas Kose and Mut, 2019). The higher ADF and NDF values reduce the digestibility and energy value of feed. On average for both vegetation seasons, the lowest ADF and NDF ratios were found in triticale variety, while the highest was in rye variety. The average ADF and NDF ratios were higher in the first year. Korkut et al. (2019) reported the triticale grains have lower ADF and NDF ratios compared to the rye grains. Kowieska et al. (2011) founded that the average ADF and NDF ratio of rye 5.14% and 21.73%, respectively.

Table 4. ADF and NDF ratio of genotypes

Genotypes	Acid detergent fiber (ADF%)			Neutral detergent fiber (NDF%)		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	4.24 bc	3.86 b	4.05 bc	26.38 ab	26.14 abc	26.26 ab
Akdag-2	3.94 d	3.76 b	3.85 d	26.37 ab	26.23 abc	26.30 ab
Bayburt	4.27 b	3.92 b	4.10 b	26.17 b	26.05 c	26.11 c
Cekerek	4.14 bc	3.77 b	3.96 bcd	26.46 a	26.27 ab	26.36 a
Kadisehri	3.94 d	3.72 b	3.83 d	26.27 ab	26.10 bc	26.19 bc
Sorgun-1	4.19 bc	3.82 b	4.01 bc	26.39 ab	26.13 bc	26.26 ab
Sorgun-2	4.03 cd	3.82 b	3.93 cd	26.33 ab	26.17 abc	26.25 abc
Yozgat-1	4.27 b	3.95 b	4.11 b	26.29 ab	26.07 c	26.18 bc
Yozgat-2	4.26 b	3.91 b	4.08 b	26.29 ab	26.15 abc	26.22 abc
Aslim-95	4.78 a	4.20 a	4.49 a	26.38 ab	26.33 a	26.36 a
Karma-2000	2.85 e	2.25 c	2.55 e	25.21 c	24.50 d	24.85 d
Mean	***4.08 A*****	***3.73 B*****		***26.23 A*****	***26.01 B*****	
LSD	***0.194***	***0.208***	***0.138***	***0.215***	***0.170***	***0.133***

**Significant differences at p< 0.01; Aslim-95: Variety of rye; Karma-2000: Variety of triticale.

Mineral matter content of grain including potassium (K) and phosphorus (P) were significantly (P<0.01) different among treatments and between years (Table 5). In combined years, K and P contents were ranged between 0.953-1.017% and 0.358-0.369%, respectively. On average of two years, the K and P contents were determined the highest (1.017 % and 0.369%, respectively) in variety of rye (Aslım-95). The lowest content of K was detected in triticale (0.941%). In terms of P, the lowest value (0.358%) was determined in the rye landrace of Yozgat-1, but it was also observed that some rye landraces (Akdag-1, Cekerek and Sorgun-1) were superior to triticale. According to the needs of cattle, the K content of the feeds should be between 0.6-0.8%, and the P content should between 0.18-0.39% (Yozgatli, 2017). In this context, the K and P contents of the examined genotypes exceed the desired values. (Table 5). Stępień et al. (2016) founded that the K and P content of rye grains were ranged between 0.385-0.495% and 0.328-0.386%, respectively while Biel et al. (2020) founded that average K and P content of triticale 0.470% and 0.385%, respectively.

Table 5. The potassium and phosphorus contents of genotypes

Genotypes	Potassium (K%)			Phosphorus (P%)		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	0.999 ab	0.962 cd	0.981 cd	0.369 ab	0.364 bc	0.366 ab
Akdag-2	0.974 c	0.953 d	0.963 e	0.361 cd	0.357 e	0.359 de
Bayburt	0.962 cd	0.952 d	0.957 e	0.361 cd	0.358 cde	0.360 de
Cekerek	1.007 a	0.983 b	0.995 b	0.369 ab	0.365 b	0.367 ab
Kadisehri	0.992 b	0.957 cd	0.974 d	0.365 abc	0.359 cde	0.362 cd
Sorgun-1	1.008 a	0.969 bcd	0.989 bc	0.370 a	0.362 b-e	0.366 ab
Sorgun-2	0.996 ab	0.972 bc	0.984 cd	0.366 abc	0.362 b-e	0.364 bc
Yozgat-1	0.954 d	0.953 d	0.953 e	0.358 d	0.358 de	0.358 e
Yozgat-2	0.992 b	0.967 bcd	0.980 cd	0.362 cd	0.361 b-e	0.362 cd
Aslim-95	0.998 ab	1.036 a	1.017 a	0.364 bc	0.375 a	0.369 a
Karma-2000	0.958 d	0.924 e	0.941 f	0.365 bc	0.363 bcd	0.364 bc
Mean	***0.986 A*****	***0.966 B*****		***0.365 A****	***0.362 B****	
LSD	***0.017***	***0.017***	***0.011***	***0.005***	***0.017***	***0.003***

*Significant differences at p< 0.05; **Significant differences at p< 0.01; Aslim-95: Variety of rye; Karma-2000: Variety of triticale.

The significant effect of genotype (p<0.01) and year (p<0.05) was noted for calcium (Ca) and magnesium (Mg) contents of the grain. In combined years, the Ca and Mg contents ranged between 0.022-0.032% and 0.130-0.138%, and determined higher in rye genotypes than in triticale. Stępień et al. (2016) reported that Ca and Mg contents were ranged between 0.052-0.059% and 0.089-0.097%, respectively. Differences can be due to several factors such as cereal type, climatic conditions, cultural applications, location and structure of grains.

Table 6. The calcium and magnesium contents of genotypes

Genotypes	Calcium (Ca%)			Magnesium (Mg%)		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	0.026 bc	0.027 abc	0.027 cde	0.140 a	0.135 bc	0.137 ab
Akdag-2	0.029 b	0.026 bcd	0.028 bcd	0.137 bcd	0.134 cd	0.135 cd
Bayburt	0.030 b	0.027 abc	0.028 bc	0.136 cde	0.132 d	0.134 d
Cekerek	0.026 bc	0.023 de	0.025 e	0.140 a	0.137 b	0.138 a
Kadisehri	0.028 bc	0.025 cde	0.026 cde	0.139 ab	0.134 cd	0.137 bc
Sorgun-1	0.022 d	0.022 e	0.022 f	0.140 a	0.135 bc	0.137 ab
Sorgun-2	0.025 cd	0.026 a-d	0.026 de	0.138 abc	0.134 cd	0.136 bc
Yozgat-1	0.037 a	0.027 abc	0.032 a	0.136 bcd	0.133 cde	0.135 cd
Yozgat-2	0.028 bc	0.028 ab	0.028 bc	0.135 de	0.133 cde	0.134 d
Aslim-95	0.029 b	0.029 a	0.029 b	0.134 ef	0.139 a	0.137 bc
Karma-2000	0.022 d	0.023 de	0.022 f	0.132 f	0.128 e	0.130 e
Mean	***0.027 A****	***0.026 B****		***0.137 A****	***0.134 B****	
LSD	***0.005***	***0.001***	***0.003***	***0.05***	***0.001***	***0.003***

*Significant differences at p< 0.05; **Significant differences at p< 0.01; Aslim-95: Variety of rye; Karma-2000: Variety of triticale.

There were significant ($p<0.01$) differences between genotypes and years in terms of total phenolic and flavonoid content (Table 7). In combined years, the total flavonoid and phenolic contents of some ryes landraces were higher than both varieties. The total phenolic and flavonoid contents of genotypes were ranged between, 4.361-5.315 mg GA g^{-1} and 0.180-0.223 mg QEg^{-1}, respectively (Table 7). Previous studies showed that flavonoids and phenolic compounds are very important for rumen health and animal productivity (Rochfort et al., 2008; Patra et al., 2016; Lee et al., 2017). In addition to, they show antioxidant and antimicrobial effects, and have significant potential to improve animal yield and quality. (O'Connell and Fox, 2001; Robbins, 2003; Santos Neto et al., 2009; Frozza et al., 2013). Seradj et al. (2014) and Paula et al. (2016) reported that the positive effect of flavonoids and phenolic compounds on the productivity and health of animals. Besides they have rumen fermentation, and control nutritional stress such as bloat and acidosis. Zilic et al. (2011) reported that the total phenolic and flavonoids contents of rye grain were ranged between 1.88-2.15 mg GAE g^{-1} and 0.027-0.031 mg QE g^{-1}, respectively.

Table 7. Total phenolic and flavonoid contents of genotypes

Genotypes	Total phenolic (mg GA g^{-1})			Total flavonoid (mg QEg^{-1})		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	5.070 d	4.247 c	4.659 cd	0.259 a	0.187 abc	0.223 a
Akdag-2	5.016 e	4.570 bc	4.793 cd	0.214 b	0.185 bc	0.200 a
Bayburt	4.920 f	5.173 a	5.047 b	0.199 bc	0.189 ab	0.194 b
Cekerek	5.571 c	4.509 bc	5.040 b	0.203 b	0.184 bc	0.194 bc
Kadisehri	6.110 a	4.520 bc	5.315 a	0.195 bc	0.193 ab	0.194 bc
Sorgun-1	4.341 k	4.381 bc	4.361 e	0.192 bc	0.199 a	0.196 bc
Sorgun-2	4.584 I	5.082 a	4.833 c	0.185 bc	0.174 c	0.180 c
Yozgat-1	5.917 b	4.697 b	5.307 a	0.202 b	0.192 ab	0.197 b
Yozgat-2	4.438 j	5.248 a	4.843 c	0.204 b	0.192 ab	0.198 b
Aslim-95	4.866 g	5.342 a	5.104 b	0.172 c	0.189 ab	0.181 c
Karma-2000	4.732 h	4.509 bc	4.620 d	0.195 bc	0.187 abc	0.191 bc
Mean	***5.051 A*****	***4.753 B*****		***0.202 A*****	***0.188 B*****	
LSD	***0.017***	***0.377***	***0.180***	***0.017***	***0.017***	***0.003***

**Significant differences at p< 0.01; Aslim-95: Variety of rye; Karma-2000: Variety of triticale

There were significant ($p<0.01$) differences between genotypes and years in terms of DPPH free radical scavenging activity and condensed tannins contents (Table 8). DPPH is one of the most important methods for evaluating the antioxidant properties plants, and they have very important effects on the prevention of animal diseases. Recently, research has also focused on supra-nutritional dietary supplementation of antioxidants in the diet to improve animal performance during environmental stress (Rooke et al., 2004). Lykkesfeldt and Svendsen (2014) indicated that there is a well-defined correlation between the onset of some diseases and a reduction in the antioxidant status in livestock. In the current study, the highest DPPH content was determined in landraces of Sorgun-1 and 2 (17.431% and 17.432% respectively). The average DPPH content first year (17.049%) was higher than a second year (15.029%) in the present study. Chua et al. (2015) reported that the DPPH antioxidant activity was negatively correlated with the temperature. As seen in the climate data, the average temperature in the first year was lower than the second year (Table 2). For this reason, the difference in DPPH may be related to the temperature of the years. Lascano and Cardenas (2010) reported that ¼ of the methane gas released into the atmosphere is produced in the digestive system of ruminants. Condensed tannins are inhibited some hydrogen-producing protozoans and methane-producing organisms that use hydrogen directly in the rumen and reduce greenhouse gas emissions (Martin et al., 2016). Besides, the condensed tannins show an anthelmintic effect, reduce animal internal parasites and increase productivity in the animals (Luscher et al., 2016). Huang et al. (2018) indicated that plants with low tannin content have a beneficial effect as they reduce protein degradation in the rumen, while Teferedegne (2007) and O'Donovan (2001) stated that high amounts of condensed tannin negatively affect protein digestion and microbial and enzyme activities. Onal Asci and Acar (2018) indicated that the feeds with low condensed tannin led to increase in protein content of milk. Accordingly, the condensed tannin content of plants is required to be 2-3% or less. In the present study, the condensed tannin content ranged between 0.156-0.264% in the combined years and below the critical level (Table 3). In previous researches, the condensed tannin content of different forage crops ranged from 0.21% to 0.45% (Bal et al., 2006; Kokten et al., 2017; Yildiz et al., 2021).

Table 8. DPPH and condensed tannins contents of genotypes

Genotypes	DPPH free radical scavenging activity (%)			Condensed tannin (%)		
	2019-20**	**2020-21****	**Mean****	**2019-20****	**2020-21****	**Mean****
Akdag-1	16.475 c	14.450 h	15.463 d	0.178 cd	0.183 d	0.181 cd
Akdag-2	18.010 b	15.189 d	16.599 bc	0.190 bc	0.174 de	0.182 cd
Bayburt	18.391 b	14.942 f	16.667 bc	0.146 de	0.158 de	0.152 e
Cekerek	15.845 c	14.039 k	14.942 e	0.164 cde	0.168 de	0.166 de
Kadisehri	14.039 d	15.886 c	14.963 e	0.284 a	0.176 de	0.230 b
Sorgun-1	18.689 ab	16.174 b	17.431 a	0.149 de	0.248 c	0.199 c
Sorgun-2	18.115 b	16.749 a	17.432 a	0.219 b	0.150 ef	0.185 cd
Yozgat-1	19.376 a	14.304 I	16.840 b	0.187 bcd	0.126 g	0.156 e
Yozgat-2	16.092 c	14.942 e	15.517 d	0.184 bcd	0.130 fg	0.157 e
Aslim-95	14.368 d	14.121 j	14.244 f	0.134 e	0.326 b	0.230 b
Karma-2000	18.144 b	14.524 g	16.334 c	0.151 cde	0.377 a	0.264 a
Mean	***17.049 A*****	***15.029 B*****		***0.180 B*****	***0.201 A*****	
LSD	***0.855***	***0.053***		***0.017***	***0.001***	***0.003***

**Significant differences at p< 0.01; Aslim-95: Variety of rye; Karma-2000: Variety of triticale

CONCLUSION

According to the two years results; it was determined that the landraces have the potential to be used as a genetic resource in breeding programs for improving the yield and quality of rye as feed. Besides, the differences were also significant among the rye genotypes.

Accordingly,

- Landrace of Sorgun-1shined out in terms of grain yield.

- A variety of Triticale shined out in terms of crude protein ratio

- The variety of Aslim with landraces of Cekerek, Akdag-1, and Sorgun-1 shined out in terms of mineral contents

- Landraces of Kadısehri, Yozgat-1, Yozgat-2, Bayburt, Sorgun-1, Sorgun-2 shined out in terms of secondary metabolites.

As a result, it was seen that especially landraces of Sorgun 1 and Sorgun 2 shined out in terms of the examined characteristics.

LITERATURE CITED

Arvouet-Grand, A., B. Vennat, A. Pourrat and P. Legret. 1994. Standardisation d`un extrait de propolis et identification des principaux constituants. J Pharm Belg. 49: 462-468.

Bagci, A., U. Gecgel, N. Dursun, M.M. Ozcan, A. Tamkoc, I. Ozer and M.M. Ozcan. 2019. The oil yield, mineral content, and fatty acid compositions of some rye (*Secale cereale*) grains. Iran. J. Chem. Chem. Eng. 38(5): 285-292.

Bal, M.A., D. Ozturk, R. Aydin, A. Erol, C.O. Ozkan, M. Ata, E. Karakas and P. Karabay. 2006. Nutritive Value of Sainfoin (*Onobrychis viciaefolia*) Harvested at Different Maturity Stages. Pak J Biol. Sci. 9: 205-209.

Bate-Smith, E.C. 1975. Phytochemistry of proanthocyanidins. Phytochemistry. 14:1107-1113.

Biel, W., K. Kazimierska, U. Bashutska. 2020. Nutritional value of wheat, triticale, barley and oat grains. Acta Sci. Pol. Zootechnica, 19(2): 19–28.

Coblentz, W.K. and R.P. Walgenbach. 2010. Fall growth, nutritive value, and estimation of total digestible nutrients for cereal-grain in the North-Central United States. J. Anim. Sci. 88: 383-399.

Chua, I. Y., P. J. King, K. H. Ong, S. R. Sarbini and P. H. Yiu. 2015. Influence of light intensity and temperature on antioxidant activity in Premna serratifolia L. J. of Soil Sci. and Plant. Nut. 15(3): 605-614.

Duddy, G., B. McLeod and M. Siddell. 2022. Feeding Cereal Grain to Livestock. https://www.lls.nsw.gov.au/__data/assets/pdf_file/0007/595330/landfact-feedinggraintolivestock-lf-ap-05.pdf.

Erbas Kose O. and Z. Mut. 2019. Determination of different origin barley cultivars in terms of grain yield and some quality traits. Anadolu J Agr Sci. 34: 184-194.

Frozza, C.O.S., C.S.C. Garcia, G. Gambato, M.D. de Souza, M. Salvador, S. Moura, F.F. Padilha, F.K. Seixas, T. Collares, S. Borsuk, O.A. Dellagostin, J.A. Henriques and M. Roesch-Ely. 2013. Chemical characterization, antioxidant and cytotoxic activities of Brazilian red propolis. Food Chem Toxicol. 52:137-142.

Gezer, K., M.E. Duru, I. Kıvrak, A. Turkoglu, N. Mercan, H. Turkoglu and S. Gulcan. 2006. Free-radical Scavenging Capacity and Antimicrobial Activity of Wild Edible Mushroom of Turkey. Afr. J. Biotechnol. 5(20): 1924-1928.

Huang, Q., L. Xiuli, Z. Guoqi, H. Tianming, W. Yuxi. 2018. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. Anim Nutr. 4: 137-150.

Kabak, D. and M. Akcura. 2017. Evaluation of the ınterrelationship among grain yield traits of rye landraces population collected from Bingol province using biplot analysis. Turkish J. Agr. and Nat. Sci. 4(2): 227–235.

Kan, A. 2015. Characterization of the fatty acid and mineral compositions of selected cereal cultivars from Turkey. Rec. Nat. Prod. 9: 124-134.

Kokten, K., M. Kaplan, V. Turan, H. Kale, E. Cacan, Y.M. Kardes, H. Tutara and E. Tal. 2017. Animal nutrition traits of different acorn species (*Quercus* sp.). In: 12th Field Crops Congress, pp: 236-240, Kahramanmaras, Turkey (In Turkish).

Korkut, Z.K., A. Balkan, L. Ozduven and O. Bilgin. 2019. Assessing of the some feeding quality characteristics of triticale in comparison with other winter cereals. Ekin J. Breed. and Gen. 5(1):24-31.

Kowieska A, R. Lubowicki, I. Jaskowska. 2011. Chemical composition and nutritional characteristics of several cereal grain. Acta Sci. Pol. Zootechnica. 10(2): 37–50.

Kumar, R. and M. Singh. 1984. Tannins: Their adverse role in ruminant nutrition. J Agric Food Chem. 32:447- 453.

Kumbasaroglu, H. and V. Dagdemir. 2010. A study on ınput demands for wheat, barley and rye production in Erzurum province. J. Agric. Sci. 16: 194-204.

Kun, E. 1996. Cereals-I (Cool Climate Cereals). Ankara University Faculty of Agriculture Publications, Publication No: 1451, Ankara.

Lascano, C.E. and E. Cárdenas, 2010. Alternatives for methane emission mitigation in livestock systems. Revista Brasileira de Zootecnia. 39: 175-182.

Lee, S.H.Y., D.J. Humphries, D.A. Cockman, D.I. Givens and J.P.E. Spencer. 2017. Accumulation of citrus flavanones in bovine milk following citrus pulp incorporation into the diet of dairy cows. EC Nutrition. 7(4):143-154.

Linina A, D. Kunkulberga, A. Kronberga, I. Locmele. 2019. Winter rye grain quality of hybrid and population cultivars. Agron. Res. 17: (Special Issue II): 1380-1389.

Luscher, A., M. Suter and J.A. Finn. 2016. Legumes and grasses in mixtures complement each other ideally for sustainable forage production. J of the Int. Leg. Soc. 12:8-10.

Luthria, D., R. Ghatak and H. Huang. 2012. Phenolic Phytochemicals from Rye (*Secale cereale* L.). Cereals and Pulses Nutraceutical Properties and Health Benefits, First Edition. Edited by Liangli (Lucy) Yu, Rong Tsao and Fereidoon Shahidi. Published by John Wiley Sons, Inc. Pondicherry, India.

Lykkesfeldt, J. and O. Svendsen, 2007. Oxidants and antioxidants in disease: oxidative stress in farm animals. Vet. J. 173(3): 502-511.

Martin, C., G. Copani and V. Niderkorn. 2016. Impacts of forage legumes on intake, digestion and methane emissions in ruminants. J of the Int Leg Soc. 12:24-25.

Mut, Z. and O.D. Erbas Kose. 2018. Grain yield and some quality properties of triticale genotypes. /Anadolu J Agr Sci. 33: 47-57.

Mut, Z., H. Akay, O.D. Erbas Kose and I. Sezer. 2022. Determining some quality properties of oat genotypes collected from the middle and west black sea region. Philipp. Agric. Sci. 105(1): 69-84.

O'Donovan, L., J.D. Brooker. 2001. Effect of hydrolysable and condensed tannins on growth, morphology and metabolism of Streptococcus gallolyticus (*S. caprinus*) and Streptococcus bovis. Microbiology. 147: 1025–1033.

Onal Ascı, O. and Z. Acar. 2018. Inorganic substances found in the structure of the plant. In: Minerals, ed. Onal Ascı O and Acar Z., 68-69, Agriculture Engineers Chamber Press, pp. Ankara.

O'Connell, J.E.O. and P.F. Fox. 2001. Significance and applications of phenolic compounds in the production and quality of milk and dairy products: a review. Int Dairy J. 11(3):103-120.

Patra, A.K., D.N. Kamra and N. Agarwal. 2006. Effect of plant extracts on in vitro methanogenesis, enzyme activities and fermentation of feed in rumen liquor of buffalo. Anim Feed Sci Technol. 128 (3-4): 276–291.

Paula, E.M., R.B. Samensari, E. Machado, L.M. Pereira and F.J. Maia. 2016. Effects of phenolic compounds on ruminal protozoa population, ruminal fermentation, and digestion in water buffaloes. Livest Sci. 185:136-41.

Raffrenato E, R. Fievisohn, K.W. Cotanch, R.J. Grant, L.E. Chase, M.E. Van Amburgh. 2017. Effect of lignin linkages with other plant cell wall components on in vitro and in vivo neutral detergent fiber digestibility and rate of digestion of grass forages. J. Dairy Sci. 100:8119–8131.

Robbins, R.J. 2003. Phenolic acids in foods. J Agric Food Chem. 51:2866–2887.

Rochfort, S., A.J. Parker and F.R. Dunshea. 2008. Plant bioactives for ruminant health and productivity. Phytochemistry. 69 (2):299–322.

Rooke, J. A., J. J. Robinson and J. R. Arthur. 2004. Effects of vitamin E and selenium on the performance and immune status of ewes and lambs. The Journal of Agricultural Sci. 142(3): 253-262.

Santos Neto, T.M., R.A. Mota, L.B.G. Silva, D.A. Viana, J.L. Lima-Filho, L.A. Sarubbo, A. Converti and A.L.F. Porto. 2009. Susceptibility of Staphylococcus spp. isolated from milk of goats with mastitis to antibiotics and green propolis extracts. Lett Drug Des. Discov. 6: 63-68.

Seradj, A.R., L. Abecia, J. Crespo, D. Villalba, M. Fondevila and J. Balcells. 2014. The effect of Bioflavex® and its pure flavonoid components on in vitro fermentation parameters and methane production in rumen fluid from steers given high concentrate diets. Anim. Feed Sci. Technol. 197: 85-91.

Singleton, V.L., R. Orthofer and R.M. Lamuela-Raventos. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Meth. Enzymol. 299:152-178.

Steel, R.G.D., J.H. Torrie. 1980. Principles and Procedures of Statistics. A biometrical approach. 2nd edition. McGraw-Hill, New York, USA, pp. 20-90.

Stępień, A., K. Wojtkoviak, M. Pietrusewicz, M. Skłodowski and R. Pietrzak-Fiečko. 2016. The yield and grain quality of winter rye (*Secale cereale* L.) under the conditions of foliar fertilization with micronutrients (Cu, Zn and Mn). Polish Journal of Natural Sciences. 31 (1): 33–46.

Teferedegne, B. 2007. New perspectives on the use of tropical plants to improve ruminant nutrition. Proc. Nutr. Soc. 59: 209–214

Van Soest, P. J., J. B. Robertson and B.A. Lewis. 1991. Methods for dietery fiber, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Yildiz, B., Y.E. Ozturk, Y.M. Kardes, H. Mut and E. Gulumser. 2021. Determination of antioxidant properties and condensed tannin content of mistletoe used as roughage. Anadolu J Agr. Sci. 36:132-137 (In Turkish).

Yozgatli, O. 2017. Determination of suitable silage corn (*Zea Mays* L.) varieties for Yozgat ecological conditions. Yozgat Bozok Un. Graduate School of Education, Department of Field Crops, MSc Thesis, Yozgat.

Žilić, S., V. H. T. Šukalović, D. Dodig, V. Maksimović, M. Maksimović and Z. Basić. 2011. Antioxidant activity of small grain cereals caused by phenolics and lipid soluble antioxidants. Journal of Cereal Sci. 54(3): 417-424.