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EVALUATION OF FORAGE YIELD AND QUALITY AT TWO PHENOLOGICAL STAGES OF TRITICALE GENOTYPES AND OTHER CEREALS GROWN UNDER RAINFED CONDITIONS

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Abstract

Forage yield and quality of triticale and some other cereals were evaluated under rainfed conditions in Samsun, Turkey, at two phenological stages in 2001 - 2002 and 2002 - 2003. The experimental design was a randomized split block design with three replicates. Twelve triticale genotypes (*Triticosecale* Withmack), one rye cultivar (*Secale cereale* L.), two barley cultivars (*Hordeum vulgare* L.) and one bread wheat cultivar (*Triticum aestivum* L.) were used. Plants were harvested at two stages, the early heading and the milk-dough stage, for the determination of their forage yield and some quality traits. Average dry matter yield across genotypes and years was 7.78 t/ha at the early heading and 13.55 t/ha at the milk-dough harvest stages. At the early heading stage, dry matter yield ranged from 6.19 to 10.16 t/ha, while it ranged from 10.92 to 14.78 t/ha at the milk-dough stage. Dry matter yields of all genotypes increased by 43% from early heading to milk-dough stage. Plant height increased from 82.1 cm at the early heading stage to 108.4 cm at the milk-dough stage. The crude ash yield changed from 0.56 (early heading harvest stage) to 0.79 t/ha (milk-dough harvest stage). Crude protein yields among the genotypes were 0.73 and 0.89 t/ha at the heading and milk-dough stages, respectively. Ca contents of the genotypes varied from 0.072 to 0.171% at the heading stage, in contrast Ca contents of the genotypes were in the range of 0.061 to 0.134% at the milk-dough stage. At both harvest stages, K, Fe, Zn, Mn and Mg contents in the forage samples were 0.998 - 2.391 %, 63.06 - 117.68, 16.99 - 69.40, 19.42 - 42.92 ppm, 0.064 and 0.124 % respectively.

Introduction

The basic goal of many grazing programs is to provide high quality forage over the years to reduce the costs of storing and purchasing concentrate feeds. No single crop has the potential to provide forage for the whole year. Therefore, new or existing forage species that have the ability to provide forage for grazing over an extended period need to be developed and evaluated.

Cereals (wheat, barley, oat, rye and triticale) are important forage for livestock. Traditionally, summer grazing and cereal straw feeding in winter are the major sources of ruminants in Turkey (Buyukburc 1993). These grain forages are versatile, economic sources of digestible fiber, protein and minerals. Forage and animal scientists are also aware of the importance of the concentrations of Ca, Mg, K, Cu, and Zn, and the K/(Ca + Mg) ratio in diets for ruminants (Kidambi *et al.* 1989).

Triticale, a cross between wheat and rye (*Secale cereale* L.), has become an interesting alternative to wheat or barley as a feed grain in areas with unfavourable growing conditions or in low-input systems (Karpenstein-Machan and Heyn 1992, Varughese 1996). Comparative trials involving various cultivars have shown that the biomass yield potential of triticale is similar to, or greater than other cereals. Triticale produces at least 20% more forage than wheat, and is higher in forage quality than rye or wheat (Koch and Paisley 2002). However the data on quality appear to be more contradictory because this parameter is linked mainly to the ripening stage at harvest (Cherney and Marten 1982, Jedel and Salmon 1994, McCartney and Vaage 1994).

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Sapra *et al.* (1973) reported that forage production of triticale was equal to that of wheat, barley (*Hordeum vulgare* L.), and rye. Brown and Almodares (1976), Finker and Fuehring (1974), and Prato *et al.* (1971) observed greater fluctuation in grain yield and protein in triticale than was reported for wheat and in other geographical areas. Forage quality of triticale, from boot to the soft-dough growth stage, was also lower than wheat forage (Tidwell *et al.* 1987).

Various agronomic factors affect the yield and quality of forage (Ayup *et al.* 1999). An important factor affecting the quality and yield of forage is the growth stage of the plant harvest (Ayup *et al.* 1999). Dry matter yield increases when the growth period before harvest extends, while certain important nutritional characteristics, such as crude protein and digestibility decreases (Ayup *et al.* 1999, Delogu *et al.* 2002). Droushiotis (1984), Ayup *et al.* (1999) and Delogu *et al.* (2002) reported that the dry matter yield of several varieties of cereals, increased significantly when harvest delayed from the booting to the grain milk stage. There is a strong relationship between morphological structure and nutritional qualities of forage crops (Acikgöz, 1991, Korkmaz *et al.* 1993). Soil has an important effect on mineral content of plants grown on it (Korkmaz *et al.* 1993). Papakosta and Gagianas (1991) reported that the protein in the leaf and stem of wheat declined from 20.5 g/kg at anthesis to 6.7 g/kg at maturity. Ayup *et al.* (1999) found that crude protein per cent in whole barley plant decreased with time and remained constant near maturity.

The objective of the present study was to assess the effect of two phenological stages, the heading and at the milk-dough stage, on dry matter yield and chemical composition of triticale genotypes and other cereals (wheat, barley and rye).

Material and Methods

This field experiment was carried out on the experimental area of Ondokuz Mayis University, Faculty of Agriculture, Department of Field Crops in Samsun located in the Blacksea coastal area (41°21' N; 36°15' E; 190 m altitude) during the growing seasons of 2001 - 2002 and 2002 - 2003.

Table 1. The soil characters of the experimental area.

Soil characters	2001-2002	2002-2003
Soil texture	Clay	Clay
Organic matter (%)	3.15%	2.93
Phosphorus content (mg/kg)	75.4	70.6
Potasium content (mg/kg)	34.3	38.3
Amount of lime	Non-limy	Non-limy
Salinity	Non-salty	Non-salty
pH	7.00	6.86
Nitrogen content (%)	0.2	0.18
Ca content (%)	0.68	0.60
Mg (%)	0.11	0.11
Zn (mg/kg)	4.09	3.05
Fe (mg/kg)	33.56	29.76
Mn (mg/kg)	55.88	50.60

Long-term mean precipitation between November and June was 470 mm. Total precipitation in the experimental area were 533 and 383 mm in the growing seasons for 2001 - 2002 and 2002 - 2003, respectively. Average temperature was 11.3 and 10.7°C during 2001 - 2002 and 2002 - 2003, respectively. The soil characters of the experimental area are given in Table 1.

Twelve triticale genotypes (*Triticosecale* Withmack), one rye cultivar (*Secale cereale* L.), two barley cultivars (*Hordeum vulgare* L.) and one bread wheat cultivar (*Triticum aestivum* L.) were used (Table 2). The experimental design was a randomized split block design with three replicates. Cutting stages (heading and milk-dough stages) were situated in main plots with cereals constituting subplots.

Table 2. Cereals used in the experiment.

Genotype	Genus/ species	Cultivars
1	Triticale	TATLICAK - 97
2	Triticale	MELEZ-2001
3	Triticale	BDMT 98/8S
4	Triticale	MIKHAM-2002
5	Triticale	KTBVD 1
6	Triticale	KTBVD 6
7	Triticale	KTBVD 8
8	Triticale	KTBVD 12
9	Triticale	KTBVD 13
10	Triticale	KTBVD 21
11	Triticale	PRESTO
12	Triticale	KARMA - 2000
13	Rye	ASLIM -98
14	Barley	KRAL - 97
15	Barley	SLADORAN
16	Wheat	KATE A-1

Seeding rates were 500 seeds/m^2. Individual plot size was 19.6/m^2 (1.4 $\times$ 14 m). Sowing was done by a standart sowing machine on 2 and 5 November in 2001 and 2002, respectively. The basic pre-sowing fertilization rates for all plots were 30 kg N/ha and 60 kg P/ha; a top dressing of 100 kg N/ha was applied to plots as follows: 50% of total N at the 3 - 4 leaf stage and the remainder at the early stem-elongation stage. Forage was harvested when each species reached the early heading stage. The rest of the plots (6.3 m^2) was harvested at the milk-dough stage.

Samples taken from each plot were dried to constant weight at 65°C in a forced-air oven. After cooling and weighing, the samples were grounded for crude protein, crude ash and mineral content analyses. Crude protein content was calculated by multiplying Kjeldahl nitrogen concentration by 6.25 (Kacar 1972); crude ash content was determined by ashing at 550°C for 6 h (AOAC 1990); mineral content of samples was calculated using Atomic Spectrophotometer after digesting the samples with $HClO_4$: HNO_3 (1 : 4) according to Kacar (1972). Crude protein and crude ash yields were calculated by multiplying dry matter yield with crude protein concentration and crude ash content, respectively. Means of treatments were evaluated and ranged according to Duncan test. The software package program MSTAT-C program was used for all statistics.

Results and Discussion

Dry matter yield: Harvest stage, cereal species and genotypes significantly ($P < 0.01$) affected dry matter yield. Average dry matter yield across genotypes and years was 7.78 t/ha and 13.55 t/ha at the heading and milk-dough harvest stages, respectively (Table 3). At the early heading stage, dry matter yield ranged from 6.19 to 10.16 t/ha, while it ranged from 10.92 to 14.78 t/ha at the milk-dough stage.

The highest dry matter yield was obtained from genotype 2 (10.16 t/ha) at the early heading stage; the highest average dry matter yield was obtained from genotype 9 (14.78 t/ha) at the milk-dough stage.

Table 3. Two-year summary of dry matter yield, plant height, crude ash yield and crude protein yield at the early heading and milk-dough stage.

Genotype	Dry matter yield (t/ha)		Plant height (cm)		Crude ash yield (t/ha)		Crude protein yield (t/ha)	
	Early heading stage	Milk-dough stage	Early heading stage	Milk-dough stage	Early heading stage	Milk-dough stage	Early heading stage	Milk-dough stage
1	7.75 cf**	14.49 ab**	81.7 bd **	118.2 b**	0.51	0.79	0.71 be*	0.93 bd*
2	10.16 a	13.68 ad	83.3 bd	110.5 cd	0.65	0.81	0.91 a	0.87 bf
3	9.76 a	14.56 ab	83.9 bd	109.5 d	0.64	0.82	0.90 a	0.97 b
4	8.05 ce	14.55 ab	79.3 de	112.2 cd	0.57	0.79	0.75 bc	0.82 cf
5	9.60 ab	14.58 ab	83.6 bd	113.5 bd	0.66	0.94	0.79 ac	0.88 be
6	7.17 dg	14.27 ac	82.5 bd	108.7 d	0.52	0.87	0.76 bc	0.96 bc
7	8.16 bd	14.06 ac	80.5 ce	113.0 bd	0.67	0.87	0.80 ab	1.12 a
8	7.18 dg	14.09 ac	80.5 ce	110.7 cd	0.52	0.74	0.64 ce	0.92 be
9	7.99 ce	14.78 a	87.3 b	113.3 bd	0.63	0.90	0.74bd	0.97 bc
10	9.11 ac	13.74 ad	82.4 bd	110.0 cd	0.60	0.80	0.92 a	0.82 cf
11	7.20 dg	13.00 bd	85.4 bc	115.8 bc	0.51	0.75	0.72 be	0.97 bc
12	6.48 eg	13.60 ad	79.9 ce	111.0 cd	0.47	0.73	0.65 ce	0.78 ef
13	7.66 cg	12.86 ce	103.8 a	147.2 a	0.53	0.74	0.60 de	0.83 bf
14	6.19 fg	11.41 ef	71.7 f	78.8 e	0.45	0.77	0.59 de	0.86 bf
15	6.86 dg	10.92 f	75.2 ef	80.3 e	0.54	0.75	0.68 be	0.73 f
16	6.21 fg	12.28 df	72.3 f	82.3 e	0.53	0.67	0.65 ce	0.80 df
Mean	7.78 B+	13.55 A+	82.1 B+	108.4 A+	0.56 B+	0.79 A+	0.73 B+	0.89 A+
CV (%)	12.14	12.14	4.96	4.96	14.58	14.58	19.55	19.55
LSD	1.40	1.40	5.124	5.124	-	-	0.129	0.129

*,**,+ In a column, values followed by a common letter do not differ significantly at 5 and 1% and the mean do not differ significantly at 1% level.

At early heading stage, the lowest average dry matter yield was obtained from genotype 14 (barley) and 16 (wheat), at the milk-dough. The lowest average dry matter was obtained from genotype 15 (barley). Dry matter of triticale genotypes were higher than barley and wheat genotypes, except triticale genotype 12 at both harvest dates.

Dry matter yields of cereals increased 43 % from early heading to milk-dough stage. These results are consistent with that of Cherney and Marten (1982), Brighnall *et al.* (1988), Bocchi *et al.* (1996) and Delogu *et al.* (2002). This finding can be attributed to the completion by the plant of its growth cycle and to the storage of newly-formed photosynthesis in the grain. The dry matter accumulated by early heading is the main factor for the yield capacity of the subsequent growth stage (Delogu *et al.* 2002). It also largely depends on the soil-climate conditions of the trial.

In the present study the highest dry matter yield was obtained from triticale (Table 3). Sapra *et al.* (1973) reported that forage yield of triticale, was equal to wheat, barley and rye yields. Poysa (1985) reported that the yield of triticale was higher than the forage yield of wheat but less than that of rye. Moreover, Crespo (1982) reported that forage yield of triticale was less than forage yield of oat, but higher than forage yield of barley at the flowering harvest time.

Plant height: The data presented in Table 3 indicate significant differences ($P = 0.05$) in plant height at early heading and milk-dough harvest stage. Plant height increased from 82.1 cm at the early heading stage to 108.4 cm at the milk-dough stage. Plant height at the milk-dough stage was higher than heading stage because plant growth continued. At both harvest dates, the maximum and minimum plant height were obtained from genotype 13 (rye) and genotype 14 (barley). Demir *et al.* (1981) reported that rye and triticale genotypes had higher plant height than wheat and barley genotypes.

Crude ash yield: Crude ash yield increased significantly ($p < 0.01$) from early heading stage to milk-dough stage. The crude ash yield increased from 0.56 to 0.79 t/ha at the early heading stage harvest and at the milk-dough stage harvest, respectively. At both harvest stages no significant differences were found between genotypes regarding crude ash yield (Table 3). Although crude ash ratio of all genotypes declined at the milk-dough stage; crude ash yield of all genotypes increased at the milk-dough stage because of high dry matter yield (Table 4). Among triticale genotypes, at the early heading stage, crude ash yield ranged from 0.47 to 0.67 t/ha, while it ranged from 0.73 to 0.90 t/ha at the milk-dough stage. These results are consistent with that of Konak *et al.* (1997) and Karadag and Buyukburc (2004).

Crude protein yield: Significant differences were found among genotypes regarding crude protein yields. Crude protein yields among the genotypes were 0.73 and 0.89 t/ha at the heading and milk-dough stages, respectively (Table 3). At the heading stage, high crude protein yields were obtained from genotype 10 (0.92 t/ha), genotype 2 (0.91 t/ha) and genotype 3 (0.90 t/ha). Genotype 14 (0.60 t/ha) and genotype 13 (0.60 t/ha) showed low crude protein yields. Regarding the milk-dough stage, the highest crude protein yield was obtained from genotype 7 (1.12 t/ha) and genotype 15 (0.73 t/ha) showed the lowest crude protein yield. These results are consistent with that of Konak *et al.* (1997) and Delogu *et al.* (2002). Brown and Almodares (1976) and Crespo (1982) reported that crude protein ratio of triticale forage was equal to crude protein content of wheat, rye and oat forages. Larter *et al.* (1968) reported that crude protein content of triticale forage was higher than wheat and rye cultivars. Crude protein yield of triticale increased from tillering stage (0.05 t/ha) to booting stage (0.20 t/ha) and ripening stage (0.57 t/ha) period depending on dry matter yield.

Rordriguez *et al.* (1990), Papakosta and Gagianas (1991) and Akgun and Kara (2002) found that crude protein content in cereals decreased to constant percentage from tillering stage and booting stage to maturity.

Mineral status: Microelement contents of the cereals are given in Table 4. At the heading stage, the highest crude ash ratio was 8.49% in genotype 16 (wheat), the lowest crude ash ratio was 6.34% in genotype 3 (triticale). At the milk-dough stage, the highest crude ash ratio was 6.80% in genotype 14 and genotype 15 (barley), the lowest crude ash ratio was 5.23 % in genotype 8 (triticale). Crude ash ratios in all genotypes decreased depending on plant growth.

Ca contents of the genotypes varied from 0.072 to 0.171% at the heading stage, while Ca contents of the genotypes varied from 0.061 to 0.134% at the milk-dough stage. Tajeda *et al.* (1985) reported that forage crops should contain at least 0.3% of Ca for ruminants. The American National Research Council (NRC 1984) recommended that forage crops should contain 3.1 g/kg Ca concentration for beef cattle. Results obtained for Ca concentration in this study were less than these recommened values. Ca intake from the soil was affected because of low Ca content in the experimental area (Table 1). Ca contents of plants in grass family (Poaceae) were lower (Acikgöz 1991).

At both harvest stages, Mg concentration in the all genotypes were between 0.064 and 0.124%. Mg concentrations for forage crops are recommended as 0.2% for ruminants by Tajeda *et al.* (1985) and 1 g/kg for beef cattle by the NRC (1984). All investigated genotypes had poor Mg concentration for ruminants. At the heading stage, K contents of the genotypes varied from 1.141 to 2.391%, while K contents of the genotypes changed between 0.998 and 1.784 % at the milk-dough stage. The highest K content was obtained from genotype 1 (Tatlicak) at both harvest stages. These results were higher than suggested values of 0.8% by Tajeda *et al.* (1985). But, high K concentration may cause Mg deficiency (Loreda *et al.* 1986).

Fe content in forage crops is recommended at least around 50 ppm for ruminants (Periguad 1970, Lamand 1975). Fe concentrations in all genotypes were higher than the suggested value at the both harvest stages. The results for Fe content in this study were similar to previous study results on forage crops found by Korkmaz *et al.* (1993) in this area.

Zn content of the genotypes varied from 25.34 to 69.40 ppm at the heading stage while Zn contents of the genotypes changed between 16.99 and 58.81 ppm at the milk-dough stage. Mostly, Zn contents of all genotypes were higher at the heading stage. Recommended Zn contents in forage crops consumed by ruminants are around 10 ppm by Danbara *et al.* (1985) and Aydin and Uzun (2002), 50 ppm by Periguad (1970) and Lamand (1975) and 30 mg/kg by McDowell *et al.* (1984) and NRC (1984). Zn deficieny in forage crops may cause infertility anemia or suppressed immune response in animals (Hidiroglou and Knipfell 1984). Furhermore, Zn contents have complex and scarcely understandable effect on the male reproductive systems (Kidambi *et al.* 1989).

Mn concentration in forage crops is recommended around 50 ppm for over consumption conditions (Periguad 1970, Lamand 1975). Mn concentration of the all genotypes varied from 19.42 to 42.92 at the both harvest stages and all samples had lower Mn concentration than the critical value of 50 ppm. Excess Mn concentration may cause appetite in animals (Danbara *et al.* 1985).

Present results showed that triticale genotypes can be grown in similar climatic conditions. It was found that dry matter, crude protein and crude ash yield of triticale genotypes were higher than those of barley, wheat and rye at both harvest times. Higher dry matter, crude protein and crude ash yield were obtained from all genotypes at the milk-dough harvest stage. Triticale genotypes can be grown instead of rye, barley and wheat genotypes for forage and should be harvested at the milk-dough harvest stage. Effects of the mineral matter deficiency in the soil reflected to forage samples. Especially the mineral matters insufficiency in the soil regarding Ca and Mg, these elements should be added into the soil. With regard to low forage quality of cereals, forage yield and quality could be increased by growing suitable triticale genotypes with legume forage crops.

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