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Full Length Research Paper

Assessing Forage Yields and Nutritional Composition in Triticale (*XTRITICOSECALE Wittmack*) Varieties: Implications for Crop Selection

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Eight lines obtained from CIMMYT and Presto and Tatlicak triticale cultivars (*x Ttriticosecale* Wittmack) were compared in a randomized complete block design with three replications during the two seasons of 2008 to 2009 and 2009 to 2010 in Amasya and Bafra conditions of Northern Turkey. Results of the present investigation clearly showed significant differences among tested lines in most of the studied characters namely, dry matter yield was 13.69 to 17.44 ton ha^{-1}, CP content was 101.71 to 117.96 g kg^{-1}, ADF content was 348.73 to 374.26 g kg^{-1}, NDF content was 572.52 to 612.98 g kg^{-1}, TDN value was 530.31 to 563.29 g kg^{-1}, RFV was 91.17 to 100.79, P content was 2.89 to 3.21 g kg^{-1}, K content was 9.68 to 14.23 g kg^{-1}, Ca content was 3.56 to 4.68 g kg^{-1}, Mg content was 1.60 to 1.83 g kg^{-1} and tetany ratio was 1.64 to 2.63. As a result of our experiments, we can conclude that the genotypes numbered 1, 3, 4, 6, 9 and 10 can be recommended for similar environment because of high forage yield and quality.

Key words: Triticale, dry matter yield, neutral detergent fiber, relative feed value, tetany ratio.

INTRODUCTION

Triticale (x*Triticosecale* Wittmack), resulting from crossing between wheat and rye, has the potential to introduce valuable economic benefits to both grain and herbage production systems (Igne et al., 2007). Triticale produces at least 20% more forage than wheat, and is higher in forage quality than rye or wheat (Koch and Paisley, 2002; Mut et al., 2006). Forage quality is affected by several factors such as the type of species, stage of crop at harvest or grazing, management practices, climate, whereas animal productivity depends on forage intake, digestibility, and nutrient utilization efficiency (Van Soest, 1982; McDonald et al., 1995; Lekgari et al., 2008). Triticale is a very important alternative forage crop to increase cultivated forage crop areas, due to its great adaptation capacity. Since, triticale adaptation capacity, it is grown in all regions of Turkey (Kara et al., 2009). The aim of this study was to determine the forage yield and quality of some triticale genotypes under two different ecological conditions of Northern Turkey.

MATERIALS AND METHODS

Eight triticale (x *Triticosecale* Wittmack) genotypes provided by CIMMYT and Presto and Tatlicak triticale cultivars were used as genetic materials which were selected from yield experiments (Albayrak et al., 2004; Albayrak et al., 2006). Field experiments were established at Bafra (41° 34´ N Latitude, 35° 54´ E Longitude, and 4 m elevation) and Amasya (40° 35´ N Latitude, 35° 39´ E Longitude, and 450 m elevation), in 2008 to 2010 growing seasons. Soil types of Bafra is clay loam, of Gökhöyük is silty clay loam. Levels of P were 195 and 150 kg ha^{-1}, levels of K were 850, and 510 kg ha^{-1}, organic matter content was 2.03, and 1.45%, and soil pH was 7.4, and 8.2 at Bafra and Amasya, respectively. Climatic data during the two growing seasons for the two locations area were presented in Table 1.

The experimental design was a randomized complete design with three replications. Number and pedigrees of triticale genotypes used in the study were shown in Table 2. Each genotype was sown in 7.2 m² (1.2 by 6.0 m) plots contain 6 rows with 20 cm apart, total plot area row seeds were shown at the beginning of November for

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Table 1. Monthly precipitation and mean temperature in the experimental areas.

Months	Amasya						Bafra					
	Precipitation (mm)			Temperature (°C)			Precipitation (mm)			Temperature (°C)		
	Long-years	2008-2009	2009-2010	Long-years	2008-2009	2009-2010	Long-years	2008-2009	2009-2010	Long-years	2008-2009	2009-2010
Nov.	64.2	25.4	43.5	8.6	8.1	8.2	97.1	140.0	95.0	12.3	12.2	11.3
Dec.	66.5	67.8	50.7	6.1	4.2	4.4	202.4	80.5	98.2	7.2	10.9	7.9
Jan.	60.2	65.0	42.9	2.7	2.2	2.8	114.4	91.5	84.8	6.6	8.0	5.6
Feb.	32.6	22.4	30.9	5.4	4.7	4.3	107.0	36.6	65.1	8.0	9.0	6.1
March	40.7	27.0	38.7	7.0	8.3	8.1	88.0	91.2	60.5	7.7	7.6	7.4
April	69.8	60.8	61.8	9.8	13.5	13.5	21.3	70.1	54.9	9.5	11.5	10.8
May	45.5	35.5	53.9	19.4	17.2	17.6	29.3	16.4	49.1	16.0	17.3	15.3
Total	379.5	303.9	322.4	-	-	-	659.5	526.3	507.6	-	-	-
Mean	-	-	-	8.4	8.3	8.4	-	-	-	9.6	10.9	9.2

Table 2. Pedigrees of triticale genotypes in present research.

Genotypes	Pedigree
1	B86-4310 /5/B86-3335/4/6TB219/6TA876//...
2	83 TR 1-11/CHD 333 85
3	HOH5/MAH 10947.1//RES-726-R
4	RES-1409-16 M5/MAH 17637.1//DAGRO
5	HOH5/MAH 10947.1//RES-726-R
6	Tatlıcak (control-1)
7	PRESTO 1RS.1DL (5+10)/4411.6
8	PRESTO 1RS.1DL (5+10) / 4411.6
9	Presto (control-2)
10	MASSA/NIMIR_3/3/YOGUI_1/TARSCA 87_3//…

both locations. Plots were fertilized with 120 kg ha^{-1} N and 80 kg ha^{-1} P in Amasya location and with 140 kg ha^{-1} N and 40 kg ha^{-1} P in Bafra location. Harvest was done at late milk dough stage (Zadok et al., 1974). After the harvest, samples taken from each plot were washed with distilled water and dried at room temperature then they were dried in oven at 70°C till they reached constant weight (Martin et al., 1990). After cooling and weighing, the samples were grounded for forage quality analyses. Dry matter (DM) yield, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), relative feed value (RFV), P, K, Ca, Mg contents and tetany ratios were investigated. Nitrogen content was calculated by Kjeldahl's method (Kacar and Inal, 2008); K, Ca, Mg contents of samples was determined using an atomic spectrophotometer after digesting the samples with $HClO_4$:HNO_3 (1:4) (AOAC, 1990); P content was determined by vanadomolibdophosphoric yellow colour method (Bozkurt and Kaya, 2010). Tetany ratios (K / (Ca + Mg)) was calculated on a milliequivalent basis (Türk et al., 2007; Türk et al., 2009).

Triticale samples were immediately dried, weighed, and ground for determinations of ADF and NDF concentrations according to standard laboratory procedures of forage quality analysis outlined by Ankom Technology (Anon., 2010). TDN, DMI, DDM and RFV were estimated according to the following equations adapted from:

TDN = (-1.291 x ADF) + 101.35
DMI = 120% NDF % dry matter basis

DDM = 88.9 - (0.779 x ADF % dry matter basis)
RFV = DDM% x DMI% x 0.775

Data obtained were subjected to statistical analysis using SAS 7.0 program. Means were compared by LSD at the 5 % level of significance.

RESULTS AND DISCUSSION

The dry matter yield of genotypes numbered 1, 2, 3, 4, 5 and 6 (13.87 to 15.45 ton ha^{-1}) were higher compared with the other genotypes in Amasya locations. The highest dry matter yield in Bafra location was obtained from genotypes numbered 1 and 6 (20.38 and 18.99 t ha^{-1}, respectively). According to an average of two locations, genotypes numbered 1 and 6 had the highest dry matter yield (17.44 and 17.22 ton ha^{-1}, respectively). More dry matter yield was produced at Bafra location than Amasya location during the growing season. This may result from the fact that, the total rainfall was much higher in Bafra location than the Amasya location. This is supported by Peltonen-Sainio and Jarvinene's (1995) studies, where they expressed that, the more the rainfall in the growing stages the better is the productive potential in triticale.

Significant differences were found among years, locations and genotypes with regards to CP, ADF, NDF, TDN, RFV, tetany ratio and mineral content of triticale forage in both Bafra and Amasya locations (Tables 2 and 3). The highest crude protein content was determined on genotypes numbered 5, 7 and 9 (119 to 22 to 126.78 g kg^{-1}) in Amasya location. In Bafra location, all triticale genotypes had similar CP contents except genotypes numbered 1, 3 and 8. In average of the two locations, the highest CP content was obtained from genotypes numbered 4, 5, 7, 9 and 10 (111.63 to 117.96 g kg^{-1}). Crude protein content of forage is one of the most important criteria for forage quality evaluation (Caballero et al., 1995; Assefa and Ledin, 2001). The protein contents of triticale genotypes investigated in the present study were similar to those reported by several researchers (Bilgili et al., 2009; Mut et al., 2006; Schwarte et al., 2005; Delogu et al., 2002).

Other important quality parameters for forages are concentrations of ADF and NDF (Caballero et al., 1995; Assefa and Ledin, 2001). ADF and NDF concentration of triticale genotypes were higher in Amasya location than Bafra location. This is in agreement with Sinclair and Seligman (1995), who explained that the lower the rainfall in growth stages, the faster the rises in the leaf/stem ratio, increasing the lignification process therefore, the amount of fiber in the forage. The environment can have a major effect on forage quality. The arid climate of Amasya had negative impact on forage yields. Van Soest et al. (1978) indicated that, warm temperatures cause plants to increase metabolism, which results in increased fiber content, which is less digestible. Also, severe drought stress can cause plant dormancy resulting in high fiber and low feed value (Lekgari et al., 2008; Lardy et al., 2004).

The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage. As ADF increases, there is a decline in TDN which means that animal are not able to utilize the nutrients that are present in the forage (Aydin et al., 2010). In the present study, TDN value was higher in Bafra location than in Amasya location. In average of two locations, the highest TDN values were obtained from genotypes numbered 3, 4, 6, 9 and 10 (551.86-563.29 g kg^{-1}). The RFV is an index that is used to predict the intake and energy value of the forages and it is derived from the DDM and dry matter intake (DMI). Forages with an RFV value over 151, between 150 to 125, 124 to 103, 102 to 87, 86 to 75, and fewer than 75 are considered as prime, premium, good, fair, poor and reject, respectively (Uzun, 2010). Relative feed value, though not a reflection of the nutrition of forage, is also important in estimating the value of forage, and all the genotypes had relative feed value ranging from 91.17 to 100.79, which is grade 4 or above (Rohweder et al., 1978; Van Soest, 1982).

There were significant differences among genotypes and years regarding to the mineral content. P contents of genotypes ranged between 3.03 to 3.23 g kg^{-1} in Amasya, while P contents of genotypes ranged between 2.75 to 3.18 g kg^{-1} in Bafra location (Table 4). Results obtained for P concentration in present study were adequate for ruminants (NRC, 1984). K contents of genotypes ranged between 12.62 to 17.62 g kg^{-1} in Amasya, while it was ranged between 5.85 to 12.05 g kg^{-1} in Bafra location (Table 4). These results are consistent with the findings of Mut et al. (2006) who studied yield and quality of triticale, rye and barley varieties. These results were higher than suggested values of 8 g kg^{-1} by Tajeda et al. (1985). However, high K concentration may cause Mg deficiency (Loreda et al., 1986).

Ca content of the genotypes varied from 3.92 to 4.68 g kg^{-1} in Amasya location, while it was varied from 3.07 to 4.85 g kg^{-1} in Bafra location (Table 4). Tajeda et al. (1985) reported that, forage crops should contain at least 3.0 g kg^{-1} of Ca for ruminants. The American National Research Council (NRC, 1984) recommended that forage crops should contain 3.1 g kg^{-1} Ca concentration for beef cattle. Our results are consistent with Tajeda et al. (1985) and (NRC, 1984). Mg content of the genotypes varied from 1.36 to 1.57 g kg^{-1} in Amasya location, while it was varied from 1.73 to 2.17 g kg^{-1} in Bafra location (Table 4). Mg concentrations for forage crops are recommended as 2.0 g kg^{-1} for ruminants by Tajeda et al. (1985) and 1 g kg^{-1} for beef cattle by NRC (1984). The most important disease for livestock is grass tetany which caused by mineral matter imbalance in feeds. Tetany is associated with Mg deficiency in the blood of animals. The threshold for risk of grass tetany increases at K / (Ca + Mg) ratio of 2.2 or higher (Elkins et al., 1977). Tetany values changed from 1.64 to 2.63 in average of Bafra and Amasya

Table 3. Dry mater yield and some quality parameters of triticale genotypes.

Genotypes	DMY (ton ha^{-1})	CP (g kg^{-1})	ADF (g kg^{-1})	NDF (g kg^{-1})	TDN (g kg^{-1})	RFV (%)
Amasya location						
1	14.51 ab	110.22 cd	387.02 a	636.57 a	513.86 c	86.05 c
2	14.61 ab	115.35 bc	380.55 ab	625.03 ac	522.21 bc	88.71 bc
3	13.87 ab	117.82 bc	366.38 bc	596.58 c	540.50 ab	94.29 ab
4	14.51 ab	113.95 bd	375.02 ac	624.08 ab	529.36 ac	89.13 ac
5	14.35 ab	119.40 ab	375.35 ab	628.37 ab	528.92 bc	88.52 bc
6	15.45 a	105.97 d	374.75 ac	619.63 ac	529.70 ac	89.89 ac
7	13.46 bc	119.22 ab	380.17 ab	624.43 ac	522.71 bc	88.39 bc
8	11.69 cd	117.10 bc	376.83 ab	631.55 ab	527.01 bc	87.83 bc
9	10.03 d	126.78 a	355.88 c	598.22 c	554.06 a	95.25 a
10	11.14 d	115.18 bc	362.75 bc	606.22 bc	545.19 ab	93.06 ab
CV (%)	11.95	6.42	4.44	4.07	4.03	6.17
Bafra location						
1	20.38 a	93.20 d	361.53 a	588.40 ab	546.76 d	96.29 ef
2	16.46 c	100.95 ad	348.13 ad	558.05 ce	564.06 ad	103.06 ad
3	16.91 bc	97.53 cd	347.83 ad	565.10 bd	564.45 ad	101.81 be
4	17.40 bc	109.32 a	340.00 cd	558.05 ce	574.56 ab	104.28 ac
5	17.15 bc	106.12 ac	356.42 ab	597.60 a	553.37 cd	95.21 f
6	18.99 ab	107.50 ab	340.42 cd	546.43 de	574.02 ab	106.53 ab
7	17.30 bc	104.82 ac	355.75 ab	582.88 ab	554.23 cd	97.69 df
8	18.15 bc	99.50 bd	351.23 ac	574.15 ac	560.06 bd	99.74 cf
9	17.34 bc	109.17 ab	344.90 bd	566.25 bd	568.24 ac	101.96 be
10	17.97 bc	109.37 a	334.72 d	538.82 e	581.38 a	108.52 a
CV (%)	10.30	8.08	3.52	3.61	2.81	5.08
Average of Amasya and Bafra locations						
1	17.44 a	101.71 c	374.26 a	612.48 a	530.31 c	91.17 f
2	15.54 cd	108.15 bc	364.34 ab	591.54 bc	543.14 bc	95.88 be
3	15.39 cd	107.68 bc	357.11 bc	580.84 cd	552.47 ab	98.05 ac
4	15.96 bc	111.63 ab	357.51 bc	591.07 bd	551.96 ab	96.70 ad
5	15.75 cd	112.76 ab	365.88 ab	612.98 a	541.14 bc	91.86 ef
6	17.22 ab	106.73 bc	357.58 bc	583.03 cd	551.86 ab	98.21 ab
7	15.38 cd	112.02 ab	367.96 ab	603.66 ab	538.47 bc	93.04 df
8	14.92 de	108.30 bc	364.03 ab	602.85 ab	543.53 bc	93.78 cf
9	13.69 e	117.96 a	350.39 c	582.23 cd	561.15 a	98.60 ab
10	14.56 de	112.26 ab	348.73 c	572.52 d	563.29 a	100.79 a
CV (%)	11.03	7.21	4.04	3.87	3.44	5.59

DMY: Dry matter yield, CP: crude protein, ADF: acid detergent fiber, NDF: neutral detergent fiber, TDN: total digestible nutrients, RFV: relative feed value. Means within a column followed by the same lowercase letter are not significantly different ($p<0.05$). Means are averaged over two growing seasons and three replicates.

locations (Table 4).

Conclusion

According to the average of the two years and locations, the highest dry matter yield was determined in genotypes numbered 1, 4 and 6, while the highest CP content was obtained from triticale genotypes numbered 4, 5, 7, 9 and 10. Genotypes numbered 3, 4, 6, 9 and 10 had high RFV and TDN values and low ADF and NDF contents. It was determined that, genotypes numbered 5, 7, 8, 9 and 10 had the highest P and K contents. The least tetany ratio was determined in triticale genotypes numbered 1, 2, 3, 4

Table 4. Mineral concentrations and tetany ratio of triticale genotypes.

Genotypes	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})	Tetany ratio
Amasya location					
1	3.03 c	13.52 cd	4.43 ac	1.40	2.33 b
2	3.11 bc	16.12 ac	4.52 ab	1.43	2.74 ab
3	3.17 ab	13.88 cd	4.68 a	1.50	2.25 b
4	3.13 ac	15.25 ac	4.52 ab	1.57	2.55 b
5	3.17 ab	17.13 ab	4.65 a	1.53	2.81 ab
6	3.03 c	12.62 d	4.22 bd	1.57	2.25 b
7	3.22 a	17.22 ab	4.08 cd	1.36	3.19 a
8	3.20 a	17.62 a	4.12 bd	1.47	3.21 a
9	3.23 a	15.37 ac	4.65 a	1.47	2.54 b
10	3.02c	14.77 bd	3.92 d	1.43	2.84 ab
CV (%)	3.15	14.56	8.41	10.35	19.31
Bafra location					
1	2.75 d	5.85 e	4.22 b	2.10 ab	0.95 e
2	3.02 ac	7.03 de	4.85 a	2.17 a	1.01 e
3	2.95 bc	8.68 bd	3.88 b	2.03 ab	1.48 ce
4	2.93 c	8.20 de	4.32 ab	2.10 ab	1.26 de
5	3.12 ab	10.32 ac	3.75 bc	1.97 bc	1.81 cd
6	2.95 bc	10.70 ac	3.92 b	2.07 ab	1.79 cd
7	3.18 a	11.23 ab	4.02 b	1.87 cd	1.92 bc
8	3.05 ac	8.35 ce	4.02 b	2.03 ab	1.39 ce
9	3.08 ac	11.18 ab	3.07 d	1.73 d	2.54 a
10	3.12 ab	12.05 a	3.20 cd	1.83 cd	2.41 ab
CV (%)	4.89	25.80	12.42	6.69	28.86
Average of Amasya and Bafra locations					
1	2.89 e	9.68 d	4.33 bc	1.75 a	1.64 d
2	3.07 bd	11.58 bd	4.68 a	1.80 a	1.87 d
3	3.06 bd	11.28 cd	4.28 bc	1.77 a	1.86 d
4	3.03 cd	11.73 bc	4.42 ab	1.83 a	1.91 cd
5	3.14 ab	13.73 a	4.20 bd	1.75 a	2.31 ab
6	2.99 de	11.66 bc	4.07 bd	1.82 a	2.02 bd
7	3.21 a	14.23 a	4.05 cd	1.62 b	2.55 a
8	3.13 ac	12.98 ac	4.07 bd	1.75 a	2.30 ac
9	3.16 ab	13.28 ab	3.86 de	1.60 b	2.54 a
10	3.08 bd	13.41 ab	3.56 e	1.63 b	2.63 a
CV (%)	4.08	18.83	10.40	8.26	22.98

P: Phosphorus, K: potassium, Ca: calcium, Mg: magnesium. Means within a column followed by the same lowercase letter are not significantly different ($p<0.05$). Means are averaged over two growing seasons and three replicates.

and 6. For the reason of high forage yield and quality, the genotypes numbered 1, 3, 4, 6, 9 and 10 can be recommended for similar environment.

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