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Comparative Performance of Triticale Genotypes in North Western Plain Zone of India for Grain Yield and its Attributes

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ABSTRACT

The man-made cereal triticale is gaining importance globally. Though, little work has been done in India yet, the results of coordinated trials conducted over two years *i.e.* 2013-14 and 2014-15 are quite encouraging. Seven triticale genotypes were evaluated against two bread wheat checks *i.e.* HD 2967 and WH 1105 in RBD design in a plot size of 2.40m x 6.0m with twelve rows in each plot spaced 20 cm with four replications at CCS HAU, Hisar research farm. The data of grain yield from each plot (middle ten rows) was obtained and expressed in quintal per hectare. The ancillary data on days to heading, days to maturity, plant height, grain texture, grain colour and thousand grain weights were taken. In 2013-14 the mean grain yield at different centres ranged from 44.5 q/ha (Gurdaspur) to 55.8 q/ha (Ludhiana) over two locations, TL 2942 exhibited the highest grain yield (56.6 q/ ha) against the bread wheat check HD 2967 (50.9 q/ha). The performance of the test entries was comparable to wheat checks for agronomy and grain characteristics. For thousand grain weight the test entry TL 2998 (49.0 g) and TL 2997 (47.0 g) showed high mean grain weight as comparable to wheat checks WH 1105 (37.0 g) and HD 2967 (41.0 g). It was interesting to note that none of the triticale line was found to be susceptible against the yellow rust while wheat check HD 2967 showed 20s yellow rust susceptibility. For days to maturity, days to heading, height and grain colour, the triticale lines were at par with wheat checks while the grain thresh-ability in wheat check was medium and texture was semi-hard whereas in triticale thresh-ability ranged from medium to hard and texture semi-hard to hard.

Keywords**:** triticale, grain yield, diseases reaction, abiotic stress

Introduction

Triticale (× *Triticosecale*) is the first reported man made cereal developed by crossing wheat (*Triticum* spp.) as a female with pollen of rye (*Secale cereale*) in 1875 to combine the positive attributes of these parents into a single plant (Wilson, 1875). Triticale genotype thus produced were called primary triticale while, secondary triticale was developed by crossing different primary triticale genotypes (Ammar *et al.*, 2004). Triticale has high yielding potential even under marginal growing conditions and it could be an attractive alternative for raising cereal production all over the world. Both hexaploid (6X; AABBRR) and octoploid (8X; AABBDDRR) types of triticale have good potential, but hexaploid triticale (Durum wheat x Rye) is most successful due to its superior vigour and reproductive stability (Mergoum et al. 2009). In general, triticale combines the high yield potential of wheat with various biotic and abiotic stress tolerance of rye, making it more suitable for marginal conditions like acidic and saline soils, or soils with heavy metal toxicity and various disease and pests' inoculums (Sharma *et al.*, 2017). Despite having many advantages over both wheat and rye, global triticale production is still very low. In 2013, about 4 million hectares of triticale was grown worldwide. Poland, Belarus, Germany, France, and Russia are the major triticale producing countries (Anonymous, 2013). Although, it has proven an important crop for changing climate, but still there is lack of research on this crop.

The low adoption of triticale is due to the factors including production concerns, availability of end-use markets, production economics, policy and strong competition from wheat. Among the production factors, its susceptibility to various diseases, such as ergot, rusts and leaf spots poses major threats. Spring triticale cultivars generally mature later than wheat, which limits its production in countries such as Canada, which has short growing season. The primary objectives for triticale improvement programs are emphasized to lower the production risks and costs of production, while increasing the economic returns per hectare. In different program on triticale breeding in worldwide, large number of genotypes of 6x triticale have been developed. These differ with each other with regard to expression of grain yield components, grain yield potential, tolerance to plant diseases and grain quality. In this study, we attempted to evaluate triticale genotypes developed at Punjab Agricultural University, Ludhiana in semi-arid ecology of Haryana state at Hisar.

Materials and Methods

The comparative yield trials were conducted over two years (2013-14, 2014-15) at various locations *i.e.* Gurdaspur and Delhi (High rainfall), Ludhiana (medium rainfall) and Hisar (low rainfall) falling in North-Western Plain Zones of India. The soils of these locations are characterized by low to medium organic carbon and low to medium nutrient pool. The data were obtained from each location, compiled and presented in All India Co-ordinated Wheat and Barley Improvement Project Progress Report, 2013-14 (Anonymous, 2014).

In these trials, seven triticale genotypes namely TL 2996, TL 2997, TL 2998, TL 2999, TL 3000, TL 2942 and TL 2969 were evaluated against bread wheat checks HD 2967 during 2013-14 while in 2014-15, triticale genotypes TL 3001, TL 3002, TL 3003, TL 3004, TL 3005, TL 2942 and TL 2969 were evaluated against bread wheat check WH 1105 in Randomized Block Design in a plot size of 2.40 m x 6.0 m with twelve rows in each plot spaced 20 cm with four replications. Sowing of these genotypes ranged from last week of October to first week of November. Various agronomic characteristics like days to heading, days to maturity, plant height and grain characteristics *i.e.* thousand grain weight and grain color were recorded. Disease reaction of two important diseases; yellow rust and black point were also recorded on plot basis. Appropriate statistical tools like analysis of variance and critical difference of mean and coefficient of variances were employed for comparative analysis.

Results

In 2013-14 the mean grain yield at different centres ranged from 44.5 q/ha (Gurdaspur) to 55.8 q/ha (Ludhiana) over two locations, TL 2942 exhibited the highest grain yield (56.6 q/ha) against the bread wheat check HD 2967 (50.9 q/ha). It was interesting to note that triticale genotypes developed at Ludhiana out yielded wheat grain yield significantly. This reveals the impact of selection intensity on triticale selectively as against wheat checks developed at other locations (New Delhi and Hisar). The performance of the test entries was comparable to wheat checks for agronomic and grain characteristics (Table 1). For days to maturity, days to heading, plant height and grain colour, the triticale lines were at par with wheat checks while the grain texture of wheat genotype was semi-hard whereas in triticale it was semi-hard to hard.

For thousand grain weight the test entry TL 2998 (49.0 g) and TL 2997 (47.0 g) showed high mean grain weight as comparable to wheat checks WH 1105 (37.0 g) and HD 2967 (41.0 g). It was interesting to note that none of the triticale line was found to be susceptible against the yellow rust while wheat check HD 2967 showed 20s yellow rust susceptibility (Table 3).

Likewise, in 2014-15 the general mean of triticale trial at different centres in NWPZ ranged from 42.5 q/ha (Hisar) to 54.4 q/ha (Ludhiana) while the general mean yield of trial at other two locations was 49.4 q/ha (Delhi) and 47.6 q/ha (Gurdaspur). At zonal level the test entry TL 3002 (51.8 q/ha) was the highest yielding genotype followed by bread wheat check WH 1105 (49.6 q/ha). The test entries TL 3003 (49.2 q/ha) and TL 3001 (48.9 q/ha) were at par with wheat check WH 1105 (Table 2). During this crop season, most of the ancillary characteristics for grain and agronomic traits were at par in wheat and triticale (Table 4). Black point incidence is considered to be negative factor; it ranged from 0 to 1.2% in triticale as against 0.2% in wheat check genotype WH 1105 while TL 3004 showed zero incidence of black point. The mean 1000-grain weight was considerably higher in TL 3004 (41.0 g) and TL 3005 (41.0 g) as against wheat check WH 1105 (37.0 g).

From trials conducted over both the years it is apparent that triticale has a competitive potential for grain yield and its attributes as well as disease resistance. Other trials conducted at Hisar exhibited higher Zn and Fe uptake as compare to wheat (Vats et al. 2016). Even under many other trials, triticale figured to have better micro-nutrient use efficiency (Kaur et al. 2007).

Conclusion

Triticale has distinct advantage over wheat to produce more grain and straw yield under restricted irrigation and nutrient supply**.** Our result has revealed that some triticale genotypes significantly out yielded wheat varieties with considerable gain yield under restricted irrigation and medium fertility (at Hisar; Table 1 and 2)**.** Location effects play important role in determining grain yield and is attributes. Similarly, triticale genotypes have shown very low reduction in yield as compared to wheat under high temperature stress conditions (Suresh et al. 2018). Other than this, triticale can be used as a fodder crop as it has a higher fodder yield and nutritional quality as compared to other fodder crops (Jindal et al. 2017). The grain of triticale has high protein content and essential amino acids due to which it can be used in the feeding of poultry and other monogastric animals like swine (Żurek et al. 2017). From these studies it is proved that triticale has a good gene pool of abiotic stress tolerant genes. We can also use these genes in wheat breeding programmes related to high temperature stress through analytical breeding.

Table 1. Location and Zonal mean yield (q/ha) of various genotypes during 2013-14.

Serial No	Genotype	Yield (q/ha)				
		Delhi	Ludhiana	Gurdaspur	Zonal	Rank
1	TL 2996	53.5	55.4	49.7	52.8	2
2	TL 2999	57.1	45.8	4.34	48.8	5
3	TL 3000	38.3	59.3	40.4	46.0	6
4	TL 2998	38.8	34.8	33.1	35.6	8
5	TL 2997	40.5	43.2	41.8	41.8	7
6	TL 2942(C)	52.2	63.7	53.9	56.6	1
7	TL 2969(C)	46.9	60.6	45.2	50.9	3
8	HD 2967(C)	61	43.5	48.2	50.9	4
G.M	-	48.5	50.8	44.5	47.9	-
C.D.	-	7.5	5.2	3.3	3.1	-
C.V.	-	10.5	6.9	5.1	-	-
D.O.S.	-	29.10.13	06.11.13	05.11.13	-	-

Table 2. Location and Zonal mean yield (q/ha) of various genotypes during 2014-15.

Serial No	Genotype	Yield (q/ha)					Rank
		Delhi	Hisar	Ludhiana	Gurdaspur	Zonal	
1	TL 3001	53.2	42.5	53.2	46.7	48.9	4
2	TL 3002	51.6	43.5	62.8	49.5	51.9	1
3	TL 3003	47.1	43.2	57.7	48.8	49.2	3
4	TL 3004	52.8	44.4	49.2	46.9	48.3	5
5	TL 3005	52.8	40.9	53.2	45.8	48.2	6
6	TL 2942(C)	47.7	40.3	48	51.3	46.8	4
7	TL 2969(C)	42.9	39.7	53.2	44.1	45.0	8
8	WH 1105(C)	47.2	45.6	57.9	47.8	49.6	2
G.M	-	49.4	42.5	54.4	47.6	-	-
C.D.	-	8.2	3.7	5.9	6.9	-	-
C.V.	-	11.3	5.9	7.4	9.8	-	-
D.O.S.	-	5.11.2014	17.11.2014	6.11.2014	6.11.2014	-	-

Table 3. Agronomic traits and disease reaction recorded on various genotypes during 2013-14.

Serial No	Genotype	Rust Reaction	Agronomic Characteristics			Grain Characteristics	
			Days to heading	Days to maturity	Plant height	Colour*	1000-grain weight
1	TL 2996	0	97	151	105	A	43
2	TL 2999	0	98	151	107	A	40
3	TL 3000	0	93	151	106	A	42
4	TL 2998	0	92	149	106	A	49
5	TL 2997	0	92	149	111	A	47
6	TL 2942(C)	0	96	149	112	A	40
7	HD 2967 (C)	20S	102	150	104	A	41
8	TL 2969(C)	0	97	150	104	A	39

A: Amber color

Table 4. Agronomic traits and disease reaction recorded on various genotypes during 2014-15.

Serial No	Genotype	Black Point	Agronomic Characteristics			Grain Characteristics	
			Days to heading	Days to maturity	Plant height	Colour*	1000-grain weight
1	TL 3001	0.2	101	152	102	A	39
2	TL 3002	0.8	97	150	105	A	39
3	TL 3003	0.2	99	150	105	A	40
4	TL 3004	0.0	100	149	101	A	41
5	TL 3005	0.4	100	152	104	A	41
6	TL 2942C)	0.4	99	151	102	A	35
7	HD 2967(C)	1.2	102	151	108	A	35
8	TL 2969(C)	0.2	105	151	100	A	37

A: Amber color

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Review Article

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Potential of Trakya Region for Production of Triticale

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ABSTRACT

This study was aimed to reveal the potential of the triticale production in the Trakya Region which exists in European part of Turkey having valuable agricultural potential. The total sowing area of the Trakya region is 19.044 km² and occupies 2.43% of total land of Turkey. About 60% of the total population of this region lives in the cities and other 40% live in rural areas. The main source of income of people in this region is agriculture. 25% of the total income in the agriculture is animal production and 75% crop production. The wheat and sunflower production are predominant in the region, and it is affected by biotic factors such as diseases and pests, and abiotic factors such as drought and high temperature in almost every year. Agro chemicals are widely used for chemical disinfection against diseases and pests in the region. Therefore, new alternative products that are less affected by biotic and abiotic factors are needed in the region. In addition, 81.2% of the agricultural areas of Trakya region are in 1-4 classes. 18.8% of it is in 5-8 classes in soil properties. In the studies conducted in the region, the triticale genotypes exhibited higher values in terms of grain and herbage yield than the other alternative cereals, especially under extreme climatic and soil conditions. Moreover due to the intensive cultural animal production in the region, the triticale production in this region has a significant chance.

Keywords**:** triticale, Trakya region, production, extreme conditions

Introduction

Triticale (x *Triticosecale* Wittmack) is an annual C3 cool-season grass within the Poaceae (Graminae) family (Kavanagh and Hall 2015). Triticale is an amphiploid species stably baring the genomes of wheat (*Triticum* sp.) and rye (*Secale* sp.) (Ammar et al. 2004). Triticale is an established small grain cereal crop that combines the productivity of wheat with the hardiness of rye. Triticale may be octoploid (2N = 56; AABBDDRR) or hexaploid (2N = 42; AABBRR) depending on which wheat is crossed with rye (RR), i.e., common wheat (AABBDD) or durum wheat (AABB). The large genome of octoploid types is less stable and with the exception of Asia cultivars; most cropping triticales are of hexaploid type (Ammar et al. 2004).

Triticale is produced in order to increase the yield of marginal and infertile agricultural lands and to provide food for the increasing world population as a result of long-lasting rehabilitation studies in many countries such as USA, Poland, Canada, and Mexico. Triticale's adaptation ability to infertile and marginal lands and yield potential are inherited from durum wheat parents which have A and B genomes, and its ability to grow on cold, acidic, and salty soils comes from rye which has R genome. Triticale has high yield potential in field conditions in which wheat and barley could not provide enough yield and qualified product. Triticale is more enduring to biotic and abiotic stress conditions compared to wheat and barley. Triticale is mostly cultivated as grain product for livestock feeding, and sometimes for roughage production and pasturage.

Triticale grain is commonly used especially for poultry feeding (Belaid, 1994). The feeding quality of its grain is equal to corn, wheat, and barley (Azman, 1997).

As triticale cultivation areas in the world are analysed considering the last 10 years' data, it can be determined that while it occupied approximately 3.2 million ha in 2002, it has raised to 4.16 million ha in 2016 with 30% increase (FAOSTAT, 2017). 80% of the world's triticale cultivation area is used for winter, and 20% for summer types (Bağcı ve Ekiz, 1993). While Poland has the widest cultivation area among the countries producing triticale with 1.4 million ha, Germany follows it with 396 thousand ha, and France with 334 thousand ha (FAOSTAT, 2017). When China, Russia, Spain, Lithuania and Hungary are included, 70% of the world's triticale cultivation is provided by these countries. Especially Russia, which first started producing triticale in 2008, has accomplished to become one of the first five countries since 2012.

For the fact that the ecological conditions in our country are quite suitable for other crops and the alternative products are easily cultivated, triticale production could not reach to the desired level. In our country since 2017, triticale has been planted on 37.6 thousand ha area and 125 thousand tons of grain product has been obtained (FAOSTAT, 2017). The average grain yield of triticale (332 kg/da) in our country is higher than the average grain yield of wheat (270 kg/da), rye (263 kg/da), barley (248 kg/da) and oat (226 kg/da).

The aim of this study is to reveal the potential of Trakya region for triticale production.

Climate and Soil Requirements of Triticale

Triticale is a cool season cereal with high yield capacity even under extreme climate and soil conditions. In our country, triticale has been better adapted to the northern transitional region, the west transitional region and Toros region, especially. It's resistance to cold and drought conditions is better than the other cool season cereals. The cultivation can be carried out in subtropical, moderately mild and moderately cold climates. Optimal temperatures are 20°C for germination, 10-24°C for optimal growth, -10°C for minimum temperature of survival and 33°C for maximum temperature of survival. Usually, the water needs of triticale range around 400-900 mm/year.

Under marginal land conditions, where abiotic stresses related to climatic (drought, extreme temperatures, etc.) and soil conditions (extreme pH levels; salinity; deficient in nutrients such as molybdenum, zinc, etc.; toxicity of trace elements such as boron, etc.) are the limiting factors for grain production, triticale has consistently shown its advantages compared to the existing cultivated cereal crops (Mergoum et al. 2004). In such problematic areas, while wheat and barley deliver 200-250 kg/da grain yield, 400 to 500 kg/da grain yield is obtained from triticale.

Climate Conditions and Soil Properties of Trakya Region

Climate conditions

Tekirdağ and Edirne provinces have sub humid climate. In Tekirdağ along the coast line, summers are hot and winters are mild, whereas Ergene Basin has continental climate. Edirne has also continental climate; summers are hot and arid, winters are too cold and harsh. However, in the southern part, in Saroz gulf and coast line, Mediterranean climate is dominant. In Kırklareli, regional characteristics determine the climate. On the northern side of the Yıldız mountains Black Sea climate is common and the temperature difference between summer and winter is low. Besides, frost is lesser than the upcountry (Anonymous, 2013).

The long-term average climate values of Trakya region provinces during triticale cultivation period are given in Table 1.

The long-term average total precipitation of Trakya region in triticale cultivation period is 547.9 mm, number of rainy days are 95, relative humidity is 71.7%, and average temperature is 13.4°C (Table 1). While the annual precipitation of Edirne (596.9 mm) and Tekirdağ (583.1 mm) is close to each other, Kırklareli's annual precipitation (463.8 mm) is lower than these two provinces (Table 1). Edirne and Kırklareli stand out as the coldest and hottest provinces in the region. In a general look, it can be said that the climate characteristics of Trakya region is quite suitable for triticale cultivation.

Soil Properties

Tekirdağ's soils which constitute the 38% of 1 million ha agricultural land of Trakya region have heavy structure. It contains more than 30% clay. Besides, in Tekirdağ, there are four kinds of soil groups which are brown forest soil group, alluvial soil group, hydromorphic alluvial soil group and limeless forest soil group (Anonymous, 2013). Among these soil groups, hydromorphic alluvial soil group is the one that does not have agricultural value.

Edirne, which has 36% of the agricultural lands of the region, generally has clayey alluvial soils. The most common soil group in Edirne is non-calcareous brown soil and non-calcareous brown forest soil (Anonymous, 2013).

Kırklareli has 26% of the agricultural lands of the region. In this province, there are 6 different soil groups, which are limeless forest soil group, calcareous forest soil group, vertosols, brown soil group, alluvial soil group, and colluvial soil group.

As Trakya region soil characteristics are evaluated in terms of triticale cultivation, it can be said that the soil structure of the region is appropriate for triticale production.

The Importance of Triticale in Trakya Region

Besides being a gate to Europe, Trakya region has a significant place in terms of agricultural potential. The region provides the 11,82% of wheat production, 80.63% of sunflower, and 56.83% of rice production. Trakya region's sunflower, wheat and rice yield is higher than the world average, even higher than some developed countries when it is examined in terms of yield in vegetative production.

Trakya region has quite suitable characteristics considering the cool climate grain production. The average yield of the cool climate grains produced in the region is much higher than the country average. Plantation, production and yields of cool climate grains cultivated in our country and Trakya region are presented in Table 2 (FAOSTAT, 2017; TÜİK, 2018). When the average grain yield of cool climate grains cultivated in our country is examined, it is obvious that triticale has higher yield with 332 kg/da compared to other cool climate grains.

As can be seen in Table 2, in Turkey, 125 thousand tons of triticale is produced on 37.6 thousand ha area with 332 kg/da average yield. As the triticale cultivation in Trakya region is investigated, it can be observed that the highest triticale production is in Edirne with 9.573 da, and it is followed by Kırklareli with 9.203 da (Table 2). The lowest triticale production is in Tekirdağ with 4.681 da. Thus the triticale yield in Trakya region is much higher than the country average. Average grain yield in Tekirdağ is 394 kg higher than country average, Edirne's average grain yield is 99 kg higher than country average, and Kırklareli's average grain yield is 79 kg higher than country average (Table 2). The average grain yield of the region (523 kg/da) is 191 kg higher than country average (Table 2).

In the light of these data, it can be said that Trakya region is very suitable for triticale cultivation in terms of the unit area yield.

The importance of triticale for land capability classes

More than the half (1.041.351 ha) of the total land property of Trakya region (1.904.383 ha) is utilized for agricultural production (Anonymous, 2013). 96.46% of agricultural lands are reserved for field crop cultivation. The share of the agricultural lands of the region in Turkey's lands is around 3.86%. The land capability classes of Trakya region is presented in Table 3 (Cangir et al. 1996).

As it is observed in Table 3, the share of I.-II.-III.-IV. class lands in the total area of Trakya region is 81.2%, the share of V.-VIII. class lands is 18.8%. This 18.8% area (357.147 ha) which is not suitable enough for cultivation is an important potential for triticale production whose adaptability to inconvenient conditions is higher than other cool climate grains.

As the provinces of the region are analyzed in terms of land capability classes, it can be concluded that V.-VIII. class lands occupy Kırklareli in the highest extent with 31.6%, and it is followed by Edirne with 14.4%. The lowest amount of V.-VIII. class lands are in Tekirdağ (Table 3). These data show that there is an important potential for triticale production in Kırklareli.

The importance of triticale for culture animal husbandry

Culture animal husbandry has recently increased in Trakya region. A large part of animals (98.28%) in the region is culture+cross-breed. The rest of it (1.72%) is constituted by native races. Trakya region's available animal stock and number of managements are given in Table 4. As the average feed consumption of the region is examined, it can be determined that roughage consumption per management is 14.6 tons/year, silage consumption 47.1 tons/year, and mixed feed as 8.18 tons/year. The husbandry managements of the region provide some of their needs from vetch+oat, vetch+wheat or vetch+triticale mixtures. Because there are too many managements in the region, the producers have problems while supplying roughage. Thus, it can be understood that triticale which has high yield potential is a significant plant which can be an alternative feed source.

The cattle culture husbandry in the region have increased in recent years. Besides, more than 100 big managements and many small cattle producers are active in the region. While the number of cattle which is in the first place in cattle farming is around 16 million, the number of sheep is around 33.6 million (TÜİK, 2017).

The investments for cattle farming in Trakya region has significantly increased in recent years. Triticale is more advantageous than cool climate grains in providing fodder for husbandry managements in the region and in the utilization of the soils which have low agricultural qualities (declivitous, hydrophilic, crop, sandy). This is also proved by the studies conducted in the region.

Korkut et al. (2009) in their study which is conducted with 9 triticale genotypes, 3 bread wheat, 3 durum wheat, 3 barley and 1 rye over three years and 3 different locations of Trakya region, revealed that triticale genotypes have average grain yield 30 kg/da higher than bread wheat, 95 kg/da higher than barley types, 63 kg/da higher than durum wheat and 121 kg/da higher than rye. They also found out that the fodder yield of triticale genotypes is 523 and 106 kg/da higher than bread wheat, 1183 and 381 kg/da higher than durum wheat, 1749 and 409 kg/da higher than barley. In the study, triticale genotypes have green grass yield 146 kg/da lower than rye, and have fodder yield 305 kg/da lower than rye. 2021 triticale lines (620 kg/da) in terms of grain yield, Tacettinbey triticale (5132.111 kg/da) in green grass, and Tatlıcak 97 triticale (1495.333 kg/da) in fodder yield have come to the foreground.

Duğan (2010), in their study which is conducted with 7 triticale genotypes, 3 bread wheat, 2 barley and 1 rye over two years and 4 different locations of Trakya region having different soil characteristics (sloping infertile and fertile soil condition) revealed that triticale genotypes grow better than other in barren and hydrophilic soils. In base soil conditions triticale is in the same statistical group with bread wheat and some triticale (Presto-2000 and Karma 2000) have higher yield than bread wheat. As a result of the study, it is revealed that triticale genotypes have grain yield 51 kg/da higher than bread wheat, 142 kg/da higher than barley, 248 kg/da higher than oat and 177 kg/da higher than rye . In terms of green grass yield, triticale genotypes' yield is 1.11 tons/da higher than bread wheat, 1.02 tons/da higher than barley, 0.11 tons/da higher than oat, and 1.01 tons/da higher than rye. The researcher also found out that triticale genotypes' forage yield is 90 kg/da higher than bread wheat, 120 kg/da higher than barley, 140 kg/da higher than oat, whereas it is 50 kg/dalower than rye.

The data from the studies conducted in Trakya region reveal that triticale has an important potential in the region. However, triticale cultivation in this region has not reached a desired level yet. The most important reason is that triticale has not been introduced to the local producers efficiently.

Results

High amounts of pesticides against agricultural diseases and pests are applied every year in Trakya region. Extensive or wrong pesticide applications and climate change have caused new types of diseases to appear in the region. In recent years, it has been observed that there is a significant increase in diseases and pests in grains.

There is also a significant increase in diseases such as yellow rust, septoria, barley yellow dwarf, besides brown rust. The most important pest of the region is sunn bug and root rot and every year it causes significant losses of wheat. These diseases are commonly seen because of the low durability of the cultivated plants in the region, and to prevent this, pesticides are being applied intensively.

Triticale is the most important candidate plant against both biotic stress factors such as disease and pests, and abiotic stress factors such as draught, high temperature and cold.

As a result, the reasons of the fact that the expected increase in triticale production in Trakya region has not come true are:

1. The local producers do not have enough information about the durability of triticale against biotic and abiotic stress factors,
2. It is not known that triticale has higher green and fodder yield compared to other grains in the region's ecological conditions,
3. The marketing price of triticale is lower than other grains,
4. Inadequate seed supply in triticale,
5. The low preference of triticale by animals as it is used in feed mixes because of its cellulose amount in its stem,
6. Marketing problems and
7. Inadequate special encouragement for low agricultural quality soils.

Table 1. The long term average climate values of Trakya region.

Months	Provinces	Total monthly precipitation (mm)	Number of rainy days	Monthly relative humidity (%)	Temperature		
					Minimum	Maximum	Avarage
October	Edirne	56,7	7,9	72	-3,3	34,1	14,2
	Kırklareli	48,4	-	72	-3,4	35,0	13,5
	Tekirdağ	55,2	7,2	76	-0,2	32,0	15,2
November	Edirne	68,8	11,3	80	-11,2	25,1	9,3
	Kırklareli	71,2	-	78	-4,3	23,3	8,9
	Tekirdağ	81,3	9,3	81	-6,9	27,9	11,4
December	Edirne	75,2	13,2	82	-17,1	20,8	4,5
	Kırklareli	76,1	-	81	-10,0	18,8	5,1
	Tekirdağ	86,2	12,0	82	-10,9	21,6	7,2
January	Edirne	62,9	13,0	81	-22,2	20,0	2,0
	Kırklareli	63,3	-	80	-15,8	18,0	2,6
	Tekirdağ	69,9	12,6	82	-13,5	21,5	4,4
February	Edirne	50,8	10,6	77	-18,9	21,1	5,2
	Kırklareli	49,7	-	78	-15,0	21,0	3,9
	Tekirdağ	54,7	10,3	80	-13,5	22,2	5,3
March	Edirne	46,2	9,7	73	-13,5	28,0	7,1
	Kırklareli	46,4	-	74	-11,8	25,7	6,7
	Tekirdağ	55,6	10,3	79	-9,0	28,1	6,8
April	Edirne	49,9	9,9	68	-2,3	33,5	12,7
	Kırklareli	44,3	-	69	-2,5	29,4	12,0
	Tekirdağ	42,9	8,9	76	-1,0	34,3	11,5
May	Edirne	49,2	10,8	67	0,6	37,1	17,9
	Kırklareli	45,8	-	66	1,8	36,0	17,0
	Tekirdağ	37,6	7,6	75	2,7	33,8	16,6
June	Edirne	48,9	8,8	62	6,7	39,3	22,0
	Kırklareli	49,7	-	62	5,8	37,0	21,2
	Tekirdağ	37,8	6,3	71	9,2	34,0	28,9
July	Edirne	32,1	5,7	56	8,0	41,5	24,4
	Kırklareli	25,2	-	59	9,0	41,6	21,3
	Tekirdağ	19,4	3,4	67	12,6	37,6	23,3
Annual	Edirne	596,9	109,4	70	-22,2	41,5	13,6
	Kırklareli	463,8	81,5	69	-20,3	40,4	12,2
	Tekirdağ	583,1	94,1	76	-13,5	37,6	14,5
Region Average		*547,9*	*95,0*	*71,7*	*-18,7*	*39,8*	*13,4*

Table 2. Plantation, production and yields of cool climate grains in Turkey and Trakya region in 2017.

Products		Turkey	Trakya region		
			Tekirdağ	**Edirne**	**Kırklareli**
Wheat	Plantation	7.6 million/ha	1.922.560 da	1.396.181 da	1.264.579 da
	Production	20.6 million/ton	882.674 tons	505.460 tons	552.431 tons
	Yield	271 kg/da	459 kg/da	362 kg/da	437 kg/da
Barley	Plantation	2.7 million/ha	130.549 da	50.067 da	45.302 da
	Production	6.7 million/ton	71.575 tons	23.821 tons	21.624 tons
	Yield	248 kg/da	548 kg/da	475 kg/da	477 kg/da
Oat	Plantation	113 thousand/ha	5.594 da	2.082 da	8.151 da
	Production	250 thousand/ton	1.908 tons	697 tons	2.523 tons
	Yield	222 kg/da	347 kg/da	335 kg/da	310 kg/da
Rye	Plantation	114 thousand/ha	1.375 da	2.226 da	1.583 da
	Production	300 thousand/ton	833 tons	1.170 tons	772 tons
	Yield	263 kg/da	606 kg/da	525 kg/da	488 kg/da
Triticale	Plantation	37.6 thousand/ha	4.681 da	9.573 da	9.203 da
	Production	125 thousand/ton	3.401 tons	4.125 tons	3.783 tons
	Yield	332 kg/da		726 kg/da	431 kg/da

Table 3. The land capability classes of Trakya region and provinces.

Provinces	Total Area (ha)	Land capability classes	
		I.-II.-III.-IV classes	**V.-VIII. classes**
Tekirdağ	621.788	558.589 (89.8%)	63.199 (10.2%)
Kırklareli	655.036	451.297 (68.4%)	203.739 (31.6%)
Edirne	627.595	537.386 (85.6%)	90.209 (14.4%)
Trakya region	1.904.419	1.547.272 (81.2%)	357.147 (18.8%)

Table 4. Number of cattle, sheep and managements in Trakya region

	Tekirdağ	Edirne	Kırklareli
Cattle	156.000	154.000	142.000
Sheep	320.000	275.000	259.000
Management	15.000	14.500	13.200

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Evaluation of Yield and Some Agro-Morphological Characters of Triticale Genotypes in Trakya Region

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ABSTRACT

Triticale under both normal and drought stress conditions were superior and also combines high plant productivity and grain yield. This research was carried out to determine the yield and agronomic performance of some triticale genotypes in Trakya region. This research was established with 16 genotypes in completely randomized blocks experimental design with 4 replications in Edirne in 2014-2015 and 2015-2016 growing seasons. In this research project grain yield, plant height, days to heading, lodging resistance, winter kill, 1000-kernel weight, test weight, protein ratio and hardness and relationships among characters were investigated. According to the results it significant differences were found among genotypes in terms of grain yield and other investigated characters. Mean yield of the genotypes was 630.7 kg/da. Entry 11 had higher gran yield with 737.8 kg/da and followed by entry 15 and entry 16. Correlation coefficients among the investigated characters showed that there were various relations among investigated parameters. Grain yield was positively correlated with 1000-kernel weight, test weight, and hardness and negatively correlated with protein ratio. Biomass at Z35 positively affected grain yield. Protein ratio was positively correlated with days to heading and plant height and negatively correlated with 1000-kernel weight and test weight. Canopy temperature was measured at Z55 and Z75 plant growth stages and there was negative relation with days to heading, plant height and protein ratio and positive relation with test weight at Z55. Biomass at Z35 growth stage had positive effect on grain yield, plant height, and protein ratio. Chlorophyll content had significantly effect on test weight. Biomass at Z25 and Z35 growth stage had positive effect on protein ratio and hardness.

Keywords**:** triticale, genotypes, yield, quality, agronomic characters

Introduction

The global warming is a major challenge for crop production. Every year temperature is rising. Also within year fluctuations in temperature is more in recent years. Under such circumstances, only resistance genotype is a solution for crop production (Suresh et al. 2018). Triticale (x *Triticosecale* Wittmack) is one of the most successful man-made cereals and was synthetized to obtain a cereal that combines the unique grain quality of its wheat (*Triticum* ssp.) parent with tolerance to abiotic and biotic stresses of the rye (*Secale* spp.) parent. It was found to have superior tolerance to low nutrient availability, drought, frost, soil acidity, aluminium and other element toxicities and salinity. Triticale has gained importance as an alternative crop to solve the nutritional problems of the rapidly increasing world population. Triticale gains the yield potential of durum wheat and adaptation of rye to cold, drought and marginal soil conditions in itself. It is also known that triticale is resistant to many diseases and pests (Çarıkçı et al. 2017). Also, triticale combines high plant productivity and grain yield (Royo *et al.*, 1999). The forage production and silage yield as well as the quality of hexaploid triticales, both as a monocrop and in small grain mixtures, have been reported to be favorable in comparison with other small grains (Erekul and Kohn, 2006; Juskiw et al. 2000; Sun et al. 1996; Rao et al. 2000). Triticale has genes for abiotic stress tolerance as most of the genotypes have shown very low heat susceptibility index (HIS) values for all the traits. Triticale has proved to be a good gene pool of abiotic stress tolerant genes (Suresh et al. 2018).

Triticale which possesses the yield potential of durum wheat and adaptation of rye to cold, drought and marginal soil conditions, has gained importance as an alternative crop to solve the nutritional problems of the rapidly increasing world population. **.** It is also known that triticale is resistant to many diseases and pests (Varghese et al. 1996). Triticale is, in general, more tolerant to environmental stresses than are wheat and barley (Jessop, 1996). The increased acceptance and production of triticale will depend on obtaining information on the extent of genetic diversity available and on the response of triticale genotypes to a wide range of environmental conditions. It is widely accepted that information regarding germplasm diversity and genetic relatedness among elite breeding material is a fundamental element in plant breeding (Siddiqui, 1994). The performance of the triticale cultivars under both normal and drought stress conditions was superior to that of wheat cultivars. The drought tolerance superiority of triticale cultivars under water-restricted conditions could be associated with their lower flag leaf angle, lower leaf area and lower number of stomata (Lonbani and Arzani, 2011). The objectives of the present study were to investigate the performance of the triticale genotype in Trakya region and to compare them with those under normal field conditions using morpho-physiological and agronomical traits.

Materials and Methods

The experiment was carried out to determine the yield and agronomic performance of some triticale genotypes in Trakya region, Turkey. This research was established with 16 genotypes in completely randomized blocks experimental design with 4 replications in Edirne in 2014-2015 and 2015-2016 growing seasons. Each plot had 6 meter long, 6 rows, spaced 0.17 meters apart. A seed rate of 500 seeds m^2 was used. In the research grain yield, plant height, days to heading, lodging resistance, winter kill, 1000-kernel weights, test weight, protein ratio and hardness and relationships between these characters were investigated. Grain yield, days to heading, plant height, 1000-kernel weights and test weight, (Blakeney et al. 2009), protein ratio, grain hardness (Köksel et al. 2000; Perten H. 1990; Anonymous, 2002; Anonymous, 1990; Blackman and Payne, 1987) were investigated.

To determination of the regression equations (R^2) were calculated (Finlay and Wilkinson, 1963; Eberhart and Russell, 1969). Also, regression graphs are used to predict adaptability of genotypes. Data were analysed statistically for analysis of variance method as described by Gomez and Gomez (1984). The significance of differences among means was compared by using Least Significant Difference (L.S.D. at a 5%) test (Kalaycı, 2005). Stability analysis of 5 wheat cultivars for all traits was also done using the model proposed by Eberhart and Russel (1966). The effect of the year and genotypes effect based on parameters and correlations between the quality parameters were determined by Pearson’s correlation analysis.

Results

Combined analysis of variance across two growing seasons revealed various variation among years and Triticale cultivars for yield, days to heading, plant height and quality characters (Table 2 and 3). According to the results significant differences were found among genotypes in terms of grain yield. During the season of 2014-2015 the mean grain yield was in the range of 488.1- 672.8 kg/da, and mean grain yield was 589.4 kg/da. During the season of 2015-2016 the grain yield per hectare of triticale genotypes ranged from 5441 to 8483 kg/ha, and mean yield was 672.0 kg/da. Averaged across years and genotypes the overall Mean yield of the genotypes was 630.7 kg/da (Table 2). The year had a significant effect on both quantity and the quality of yield in the different triticale genotypes. In 2015-2016 mean yield was higher than first year. Based on mean value of both years Entry 11 had higher gran yield with 737.8 kg/da and followed by entry 15 and entry 16.

Based on the mean days to heading, genotypes showed statistically significant ($p<0.01$) differences. The late heading was in Focus while G9 and TVD18-2013 were the early genotypes. Plant height is very important character due to lodging resistance. Plant height ranged between 100.0 cm and 135.0 cm in genotypes. Short plant height was scaled in G16 with 100 cm, and followed by G13 and TVD18-2013. The mean plant height was 118.4 cm. For lodging resistance 1-9 scale was used where 1 means very resistance to lodging and 9 very susceptible. Based on lodging resistance score G16, Focus, G8, G11 and G15 were tolerant to lodging.

Test weight is the weight of a specific volume of grain and is an indication of the bulk density of the grain. It reflects the extent of grain filling and the potential for flour yield (Blakeney et al. 2009). Based on mean value of the genotypes, the highest mean values of test weight were determined in G13 (74.7 kg), G14 (74.0 kg) and cultivar Karma 2000 (73.9 kg) while the lowest values were in genotypes Focus, G8, and G9. The highest mean values of 1000-kernel weight were observed in G15 (43.4 g), G12 (43.3 g) and G11 (42.4 g) while the lowest values were obtained in Focus and MIKHAM-2002 cultivars.

Results revealed significant differences ($p<0.01$) in protein content among growing years and triticale genotypes. Protein content of the genotypes varied between 10.2% and 12.7%, mean protein content was 11.8%. Hardness in triticale genotypes varied from 40.5 to 55.5 and mean was 44.8 (Table 3).

The effect of the year and genotypes effect based on parameters and correlations between the investigated parameters were determined by Pearson's correlation analysis. Correlation coefficients among the tested characters in 2014-2015 growing season are given Table 4. Different relations were found among investigated parameters. Grain yield was positively correlated with 1000-kernel weight (r=0.506), and test weight (r=0.154) but negatively correlated with protein ratio (r=-0.433). Biomass at Z35 positively affected grain yield. There was negative relation between winter kill with days to heading (r=-0.842**) and plant height (r=-0.603*). Genotypes damaged by winter kill had short plant height and reduced days to heading. Also, winter kill caused an increase in canopy temperature and chlorophyll content in genotypes. Cold damage caused sparse plant stand on plots and increased 1000-kernel weight in genotypes. Protein ratio was positively correlated with days to heading and plant height but negatively correlated with 1000-kernel weight and test weight. Cold damage reduced biomass therefore negative relation was found between cold damage and NDVI (Z35) (r=-0.788**).

Days to heading was negatively correlated with lodging resistance (r=-0.585*), test weight (r=-0.324), canopy temperature at Z55 (r=-0.716**), and chlorophyll content (r=-0.519*). Days to heading was positively correlated with plant height (r=0.587*), protein ratio (r=0.334), and NDVI at Z35 (r=0.782**). There was negative association between plant height with hardness, and CT at Z55 and Z75. Plant height was positively related with NDVI at Z35 (r=-0.716**). Hardness in grain had negative correlation with plant height (r=-0.458) and lodging (r=-0.246). Canopy temperature was measured at Z55 and Z75 plant growth stages and there were negative relation with days to heading, plant height and protein ratio and positive relation with lodging and test weight at Z55. Biomass at Z35 growth stage had positive effect on grain yield (r=0.239), plant height (r=0.620*), and protein ratio (r=0.457). The higher biomass at Z35 growth stage caused various levels of reductions in 1000-kernel weight and test weight. Chlorophyll content had significant positive effect on test weight (r=0.686). Tall genotypes had higher test weight and protein ratio and lower 1000-kernel weight, canopy temperature.

Correlation coefficients among the tested characters in 2015-2016 growing season are given Table 5. Different relations were found among investigated parameters. Grain yield was positively correlated with 1000-kernel weight (r=0.832**), test weight (r=0.632**), and hardness (r=0.382). There was negative relation between plant height with grain yield and winter kill. It means that winter type genotypes had higher grain yield than facultative types. 1000-kernel weight was negatively correlated with days to heading (r=-0.469) and plant height (r=-0.829**). There was negative relation between test weight and days to heading (r=-0.736**) and plant height (r=-0.489). Hardness in grain was negatively correlated with plant height (r=-0.572*) and lodging (r=-0.334), while there was positive correlation with TKW (r=0.333), and protein ratio (r=0.532*). Biomass (NDVI) was scaled at Z25 and Z35 plant growth stages. The higher biomass during Z25 and Z35 growth stage had negative effect and caused various decline on grain yield (r=-0.311; r=-0.615*) because of the cold damage. Higher biomass at Z25 and Z30 growth stage led to various level of reductions in 1000-kernel weight and test weight. Also, there was positive correlation between biomass at Z25 and Z35 growth stage and protein ratio and hardness. Facultative type genotypes had higher flag leaf area and due to cold damage negative relation between grain yield and flag leaf area was found . Tall genotypes had higher biomass and significant positive relation was found between flag leaf area and plant height (r=0.823**). Genotypes which have higher flag leaf have been lower TKW and test weight.

In 2014-205 cropping season in triticale genotypes some parameters were investigated and some relation showed (Figure 1). Lower temperature caused cold damage in genotypes, reduced plant height and increased CT at Z55. So positive relation was found between cold damage and CT (Z55) (R^2=0.457) and negative relation with plant height (R^2=-0.363). Chlorophyll content (SPAD Z55) had a positive effect on test weight (R^2=0.470). Canopy temperature at

Z75 plant growth phase led to reduced test weight in genotypes (R^2=0.397) (Figure 1).

In 2015-2016 cropping season in triticale genotypes some parameters were investigated and some relation showed (Figure 2). Grain yield was positively associated with test weight (R^2=0.691) and negatively associated with plant height (R^2=-0.679). Flag leaf area had positive correlation with biomass (NDVI Z35) (R^2=0.547) and negative correlation interaction with 1000-kernel weight (R^2=-0.602) (Figure 2). Lower temperature caused cold damage in genotypes and reduced plant biomass. Due to reduced biomass, negative association was found between winter kill and NDVI (Z35) (R^2=-0.565) and flag leaf area in triticale genotypes (R^2=-0.616).

Conclusion

According to the results significant differences were found among genotypes in terms of grain yield and other parameters. In 2015-2016 mean yield was higher than 2014-2015 cycles. Correlation coefficients among the tested characters showed that there were various relations among investigated parameters. Grain yield was positively correlated with 1000-kernel weight, and negatively correlated with protein ratio. Biomass at Z35 positively affected grain yield. Protein ratio was positively correlated with days of heading and plant height but negatively correlated with 1000-kernel weight and test weight. Days to heading was negatively correlated with lodging, test weight, canopy temperature at Z55, and chlorophyll content. Canopy temperature was measured at Z55 and Z75 plant growth stages and there was negative relation with days to heading, plant height and protein ratio and positive relation with lodging and test weight at Z55 plant phase. Biomass at Z35 growth stage had positive effect on grain yield, plant height, and protein ratio. The higher biomass at Z35 growth stage caused various levels of reductions in 1000-kernel weight and test weight. Chlorophyll content had significantly affect on test weight. Correlation coefficients among the tested characters in 2015-2016 growing season showed various relations among investigated parameters. Grain yield was positively correlated with 1000-kernel weight, test weight, and hardness. 1000-kernel weight was negatively correlated with days to heading and plant height. There was negative relation between test weight and days to heading and plant height. Biomass at Z25 and Z35 growth stage had positive effect on protein ratio and hardness.

Table 1. Rainfall mean and maximum temperature in 2014-2015 and 2015-2016.

Months	Rainfall (mm)		Max. temperature (°C)		Mean temperature (°C)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
October	121.8	52.6	26.8	26.2	12.8	15.6
November	43.2	26.2	23.4	25.1	11.0	13.5
December	111.3	0.3	12.1	14.9	2.7	5.5
January	42.2	114.8	17.3	18.4	5.5	2.8
February	68.6	91.4	20.2	22.2	7.6	9.2
March	67.8	54.8	23.7	23.3	10.1	10.2
April	44.4	116.1	25.5	31.8	13.6	15.5
May	45.2	81.4	32.1	32.2	18.6	17.4
June	31.0	10.2	33.6	38.4	22.9	23.9
Total	575.5	547.8				
Average			23.8	25.8	11.6	12.6

Table 2. Mean grain yield of the genotypes based on two cropping seasons.

Entry	Genotypes	Years		Mean yield (kg/da)
		2014-2015	2015-2016	
1	Karma 2000	581.0 c-f	613.9 ef	597.4 e-h
2	Presto	570.3 def	617.8 ef	594.0 fgh
3	Tatlıcak 97	648.6 ab	638.3 de	643.4 b-e
4	Focus	602.5 bcd	547.6 f	575.1 hı
5	MİKHAM 2002	569.6 def	598.3 ef	584.0 ghı
6	TVD18-2013	600.9 bcd	660.3 de	630.6 c-g
7	CTWS95WM00095S-7FM-030FM-3FM-0FM-0FM	542.9 ef	711.3 bcd	627.1 d-g
8	CTWW95WM00004S-2WM-030WM-2WM-0WM-0WM	528.8 fg	544.1 f	536.4 ı
9	CTSS00B00197S-0M-4Y-010M-3Y-4M-0Y	586.9 cde	666.0 cde	626.5 d-g
10	CTSS01B00020S-3M-9Y-3Y-2M-0Y	488.1 g	701.6 bcd	594.8 fgh
11	CTSS01B00022S-5M-8Y-2Y-4M-0Y	627.3 abc	848.3 a	737.8 a
12	CTSS00Y00230S-0Y-0M-10Y-6M-3Y-4M-0Y	672.8 a	679.4 cde	676.1 bc
13	CTSS04Y00163S-102Y-06M-06Y-2M-3Y-0M	555.5 def	711.3 bcd	633.4 c-f
14	CTSS04Y00163S-102Y-06M-06Y-5M-1Y-0M	630.6 abc	704.7 bcd	667.6 bcd
15	CTSS03Y00089T-050TOPY-19M-4Y-06Y-1M-1Y-0M	625.2 abc	744.3 bc	684.8 b
16	CTSS03Y00089T-050TOPY-19M-4Y-06Y-1M-2Y-0M	599.9 bcd	765.6 b	682.7 b
Mean		589.4	672.0	630.7
L.S.D (0.05)		53.1**	81.4**	47.7**
C.V (%)		6.3	8.5	7.6

Table 3. Mean value of the investigated parameters of the genotypes.

Entry	Genotypes	WK	DH	PH	LOD	TKW	TW	PRT	HARD
1	Karma 2000	1.5 cde	106.0 d	126.5 ab	5.5 cd	37.8 a-d	73.9 ab	12.2 ab	43.0 cde
2	Presto	2.0 b-e	105.5 de	131.5 ab	5.0 de	35.8 bcd	72.8 abc	12.4 ab	43.0 cde
3	Tatlıcak 97	1.0 de	116.0 ab	135.0 a	5.5 cd	34.5 d	71.7 abc	12.2 ab	42.5 def
4	Focus	0.5 e	120.5 a	129.5 ab	4.0 ef	33.8 d	61.9 d	11.3 b-e	41.5 ef
5	MİKHAM-2002	2.0 b-e	103.5 def	135.0 a	7.5 ab	33.5 d	72.6 abc	12.7 a	43.5 cde
6	TVD18-2013	4.0 a	101.0 ef	107.5 de	7.5 ab	39.2 a-d	71.7 abc	11.8 abc	45.0 bc
7	G7	2.5 a-d	103.0 def	115.5 cd	6.5 bc	36.3 bcd	72.7 abc	12.4 ab	46.5 b
8	G8	0.5 e	111.5 bc	128.0 ab	4.0 ef	34.6 cd	68.6 c	12.7 a	44.5 bcd
9	G9	3.0 abc	100.0 f	113.5 cd	7.0 b	41.2 ab	69.5 bc	12.6 a	44.5 bcd
10	G10	4.0 a	105.5 de	115.5 cd	5.5 cd	37.7 a-d	73.9 ab	11.6 a-d	42.5 def
11	G11	3.5 ab	107.0 cd	109.5 de	4.5 de	42.4 ab	73.3 abc	11.6 a-d	42.0 ef
12	G12	3.0 abc	105.0 de	121.5 bc	5.0 de	43.3 a	71.7 abc	10.2 e	40.5 f
13	G13	3.5 ab	103.0 def	106.0 de	8.5 a	39.2 a-d	74.7 a	10.5 de	43.5 cde
14	G14	2.5 a-d	105.5 de	110.0 de	7.0 b	37.9 a-d	74.0 ab	10.8 cde	44.5 bcd
15	G15	3.0 abc	105.5 de	109.5 de	4.5 de	43.4 a	71.4 abc	12.1 ab	54.5 a
16	G16	3.0 abc	106.0 d	100.0 e	3.0 f	41.1 abc	71.1 abc	12.2 ab	55.5 a
Mean		2.5	106.5	118.4	5.6	38.2	71.6	11.8	44.8
C.V (%)		29.2	2.1	4.0	8.6	8.1	3.1	5.1	2.3
L.S.D (0.05)		1.53**	4.79**	10.11**	1.04**	6.62ns	4.72**	1.29**	2.25**
F year		**	**	ns	**	**	**	**	**

Note: Significant at **: P<0.01; *: P<0.05; GY: Grain yield (kg da-1), DH: Days to heading, PH: Plant height (cm), LOD: Lodging resistance (1-9), TKW: 1000-kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%), HARD: Hardness (PSI)

Table 4. Correlation coefficients among yield, quality and physiological characters in 2014-2015 growing years.

Traits	GY	WK	DH	PH	LOD	TKW	TW	PRT	HARD	Z55 CT	Z75 CT	Z55SPAD
WK	0.035											
DH	0.008	-0.842**										
PH	0.093	-0.603*	0.587*									
LOD	-0.152	0.417	-0.585*	-0.229								
TKW	0.506	0.364	-0.192	-0.253	-0.397							
TW	0.154	0.135	-0.324	0.203	0.301	0.093						
PRT	-0.433	-0.483	0.334	0.387	-0.262	-0.444	-0.307					
HARD	0.047	0.041	-0.144	-0.458	-0.246	0.333	-0.107	0.182				
Z55 CT	-0.007	0.676**	-0.716**	-0.407	0.414	0.018	0.440	-0.325	-0.053			
Z75 CT	0.051	0.216	-0.107	-0.340	-0.148	0.110	-0.631**	0.249	0.332	0.014		
Z55SPAD	-0.164	0.491	-0.519*	0.054	0.228	0.261	0.686**	-0.117	-0.175	0.464	-0.420	
Z35 NDVI	0.239	-0.788**	0.782**	0.620*	-0.420	-0.163	-0.289	0.457	-0.035	-0.616*	0.228	-0.581*

Note: Significant at **: P<0.01; *: P<0.05; GY: Grain yield (kg/da), WK: Winter kill (0-9), DH: Days to heading, PH: Plant height (cm), LOD: Lodging resistance (1-9), TKW: 1000-kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%), HARD: Hardness (PSI), CT: Canopy temperature (°C), SPAD: Chlorophyll content, NDVI: Normalized difference vegetative index

Table 5. Correlation coefficients among yield, quality and physiological characters in 2015-2016 growing years

Traits	GY	WK	DH	PH	LOD	TKW	TW	PRT	HARD	Z25 NDVI	Z35 NDVI
WK	0.749**										
DH	-0.313	-0.549*									
PH	-0.824**	-0.786**	0.323								
LOD	-0.149	0.204	-0.500*	0.123							
TKW	0.832**	0.773**	-0.469	-0.829**	-0.043						
TW	0.632**	0.741**	-0.736**	-0.489	0.391	0.508*					
PRT	0.021	-0.010	-0.426	0.020	0.039	-0.010	0.245				
HARD	0.382	0.281	-0.255	-0.572*	-0.334	0.333	0.124	0.523*			
Z25 NDVI	-0.311	-0.609*	0.460*	0.286	-0.156	-0.498*	-0.498*	0.349	0.200		
Z35 NDVI	-0.615*	-0.752**	0.511*	0.477	-0.268	-0.668**	-0.685**	0.329	0.172	0.829**	
FLA	-0.832**	-0.785**	0.300	0.823**	-0.076	-0.776**	-0.627**	0.332	-0.129	0.556*	0.740**

Note: Significant at **: P<0.01; *: P<0.05; GY: Grain yield (kg/da), WK: Winter kill (0-9), DH: Days to heading, PH: Plant height (cm), LOD: Lodging resistance (1-9), TKW: 1000-kernel weight (g), TW: Test weight (kg), PRT: Protein ratio (%), HARD: Hardness (PSI), NDVI: Normalized difference vegetative index, FLA: Flag leaf area (cm^2)

Figure 1. Some pairwise relationship among investigated parameters in 2014-2015 cycles.

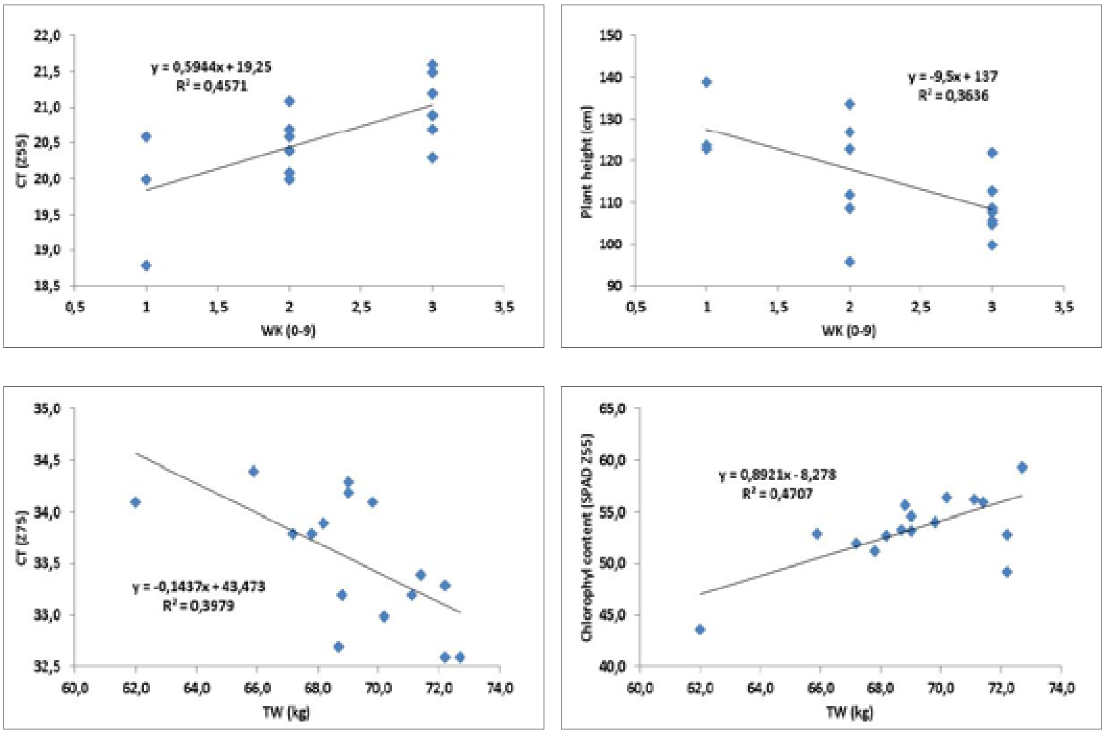
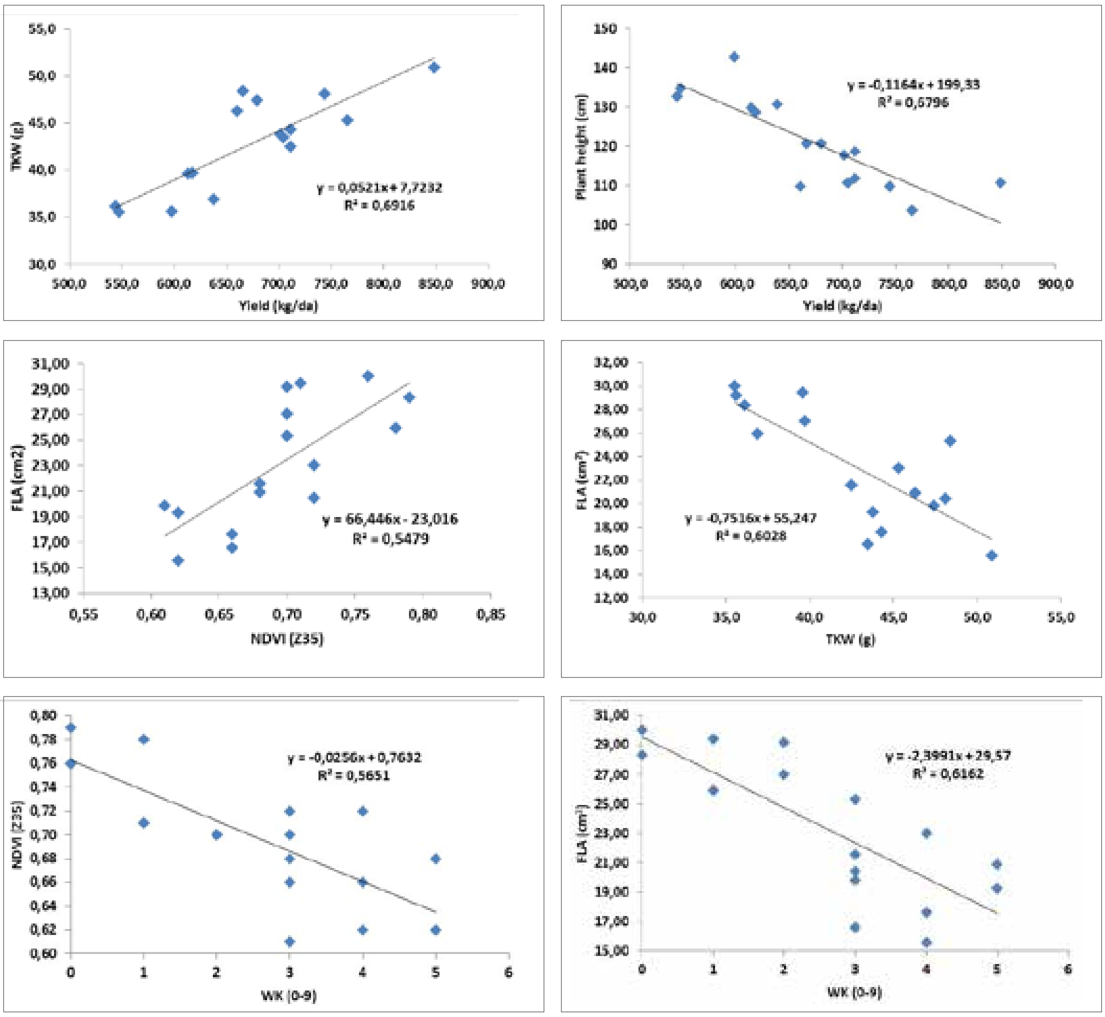


Figure 2. Some pairwise relationship among investigated parameters in 2015-2016 cycles.



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Assessing of the Some Feeding Quality Characteristics of Triticale in Comparison with Other Winter Cereals

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ABSTRACT

The study was carried out with 20 winter cereal genotypes including 3 triticale, 2 rye, 3 bread and 3 durum wheat, 3 two-rowed and 3 six-rowed barley and 3 oat in two different locations (Tekirdağ and Luleburgaz) in 2015-2016 growing years. Protein content, fat content, moisture content, ash content, cellulose, starch, NDF, ADF and ADL properties were investigated in the sample obtained from whole plant parts. It was determined that protein content ranged between 11.2-11.8% for rye, 12.4-13.6% for bread wheat, 13.9-15.4% for durum wheat, 12.4-15.5% for barley, 10.0-13.2% for oat and 13.3-14.8% for triticale. The fat ratio ranged from 1.5-1.7% for rye, 1.4-1.5% for bread wheat, 1.6-1.7% for durum wheat, 1.6-1.8% for barley, 1.1-1.6% for oats and 1.5-1.5% for triticale. The ash content was found to be 1.6-1.7% for rye, 1.4-1.5% for bread wheat, 1.5% for durum wheat, 2.0-2.6% for barley, 1.5-2.1% for oats and 1.6% for triticale. The cellulose ratios ranged between 2.7-2.9% for rye, 2.5-2.7% for bread wheat, 2.6-2.8% for durum wheat, 4.6-5.1% for barley, 10.0-13.2% for oats and 4.5-8.4% in triticale. The starch ratios for rye, bread wheat, durum wheat, barley, oat and triticale ranged from 57.7-59.1%, 58.7-59.9%, 57.0-59.0%, 48.3-51.1%, 42.0-50.3% and 57.2-58.6%, respectively. NDF ratios were calculated at intervals 13.61-15.85% for rye, 15.70-23.56% for bread wheat, 18.56-20.50% for durum wheat, 19.56-30.64% for barley, 20.25-22.61% for oat and 13.87-18.80% for triticale. ADF ratios ranged between 3.77-5.61% for rye, 4.78-7.88% for bread wheat, 4.02-5.38% for durum wheat, 5.56-9.48% for barley, 5.56-6.75% for oat and 5.1-5.55% for triticale. ADL ratios of the varieties investigated ranged from 1.62-2.47% for rye, 1.61-2.85% for bread wheat, 0.83-2.25% for durum wheat, 0.96-1.99% for barley, 0.96-1.79% for oat and 1.27-1.50% for triticale.

Keywords: triticale, protein ratio, fat content, ash content, cellulose, starch, NDF, ADF

Introduction

The name Triticale was first introduced in a literature published in Germany in 1935. It is believed that the Triticale work began with wheat/rye hybrids in Scotland in 1875. While the first hybrids obtained from these studies were sterile (Stallknecht et al. 1996), the first fertile hybrid plants were obtained by the German breeder Rimpau (McGoverin et al. 2011). In this way, it is aimed to combine the grain quality characteristics of wheat with the tolerance and/or resistance characteristics of rye to biotic and abiotic stress conditions. Worldwide wheat x rye hybridization studies have been started in countries like Russia, Sweden, Switzerland, Hungary, Germany, Spain and Canada since 1930's and then the first commercial triticale variety was registered in 1968 in Hungary. Now a days, winter, summer and alternative type of triticale varieties have been improved. Germany, Poland, Canada, China, Australia, France, and Mexico are the most triticale producer worldwide (Ammar et al. 2004). Triticale (× *Triticosecale Wittmack*), a cross of wheat and rye and known as the first man-made cereal, is more tolerant of biotic and abiotic stress conditions than wheat. It is therefore a more suitable plant for marginal areas (Villegas et al. 2010). Triticale has high yield, broad adaptability and high nutrient content compared to other cool season cereals, (Oettler, 2005). Especially, the importance of triticale as an alternative plant is increasing day by day for areas that are not suitable for wheat production, where the depth of the soil is low, the barren and the winters are very hard, and for the closing of the increased feed shortage. The first studies on triticale in our country were initiated by Osman Tosun in the 1940's and continued with the researches made by Ibrahim Demir on summer varieties in the 1970's (Demir et al. 1986). The first registered triticale variety for our producers was Tatlıcak 97 (Kınacı and Kınacı, 2000).

Due to its plant characteristics, triticale has a long plant height, but it is very resistant to laying due to its sturdy handle property. Triticale, which has more green plant parts than wheat, comes to harvest earlier than wheat. The development of varieties of triticale, which can be grown especially in fields that are not suitable for wheat and barley production, are priority breeding purposes. It is also among the other breeding purposes that livestock can be fed and be regarded as a food source for humans. It has been determined that triticale genotypes give better results in inefficient soil area, on suitable soil for agriculture and sloping areas as well as in productive areas due to their yield and quality characteristics compared to other cool climate cereals (Korkut et al. 2007; Korkut et al. 2009, Duğan, 2010).

In recent years, abiotic and biotic stress factors have caused significant loss of crop production. In order to reduce these losses, excessive agrochemical use is being carried out in some regions, especially in the region of Thrace. This causes increase in costs and changes in ecological structure. It has been shown that triticale can easily be grown in diseases, harmful, drought, acidic and troubled soil, and is an alternative to feed plants (Furan et al. 2005). Triticale has taken its potential to adapt to marginal areas and yield potential for pasta. On the other hand, the ability to grow in cold, acidic, saline soils is taken from the rye (Turan, 2008).

Feeding pea and vetch are the most preferred species in meeting the need of dry weed in animal production in Marmara region. When these plants are harvested during full bloom period, weeds contain about 20% crude protein. It is common practice to cultivate these plants by mixing them with an appropriate grain in the production of hay. A mixture of plants viz., barley, wheat, oats and triticale are used. Barley is preferred for blends because of its rapid growth and the suppression of weeds, but it is not desirable because it reduces the nutritional value in the case of delayed form due to the awn character. Özduven et al. (2010), in silage samples opened at the end of fermentation period of 45 days triticale silage, pH value, crude protein, lactic acid, acetic acid contents and silage loss ratios were found, respectively 4.5%, 8.5%, 7.3%, 5.0% and 5.8%. Demirci et al. (2011) reported that the pH value, HP, LA and AA contents were 4.6%, 13.6%, 5.3% and 2.3%, respectively, in the silages prepared from the mixture of 30% triticale + 70% others. Triticale is grown in all types of soil, but also at very high durability and high yields in arid areas. Triticale growing in the Marmara region is increasing day by day.

There are very few studies on the quality characteristics of the triticale genotypes in the region. It was aimed to determine the ranges in some quality characteristics of 20 genotypes including 3 triticale, 2 rye, 3 bread wheat, 3 durum wheat, 6 barley and 3 oat varieties in the study. The triticale genotypes in the study were compared with cool season cereals which could be used for the same purpose. The quality characteristics of the other plants used in the grass mixtures and of the triticale were compared.

Materials and Methods

In the study, 1. Aslım (rye), 2. Esperia (bread wheat), 3. Golia (bread wheat), 4. Karma 2000 (triticale), 5. Kızıltan 91 (durum wheat), 6. NKU Ziraat (durum wheat) 7. Pedujevo (rye), 8. Presto (triticale), 9. Selimiye (bread wheat), 10. Sladoran, (barley), 11. Herb, 12. Tatlıcak 97 (triticale), 13. Zenit (durum wheat) 14. Barberousse (barley), 15. Bolayır (barley), 16. Harman (barley), 17. Kırklar (oat), 18. Lord (barley), 19. Martı (barley) and 20. Sebat (oat) varieties was used as genetic material.

The study was established in the experimental areas of Tekirdag NKU Faculty of Agriculture Field Crops Department. The experiment was carried out in 3 replicated Tekirdağ and Lüleburgaz locations according to randomized completed block design.

In the study, genotypes were sown as 3 replications in total 6 m^2 parcels with 1.2 x 5 meter with parcel sowing machine in each location.

In the study, chemical pesticides were applied against weeds. Plant samples were taken for measurements and weights in the plants that came to the harvest maturity and the plants were harvested by parcel harvesting. Crude protein, crude fat, dry matter, crude ash, crude cellulose and starch analyzes were performed according to AOAC (1990) in the genotypes studied in the study. Analysis of insoluble fiber (NDF), acid soluble insoluble fiber (ADF) and acid soluble insoluble lignin (ADL) in neutral solvents were determined according to the method reported by Goering and Van Soest (1983).

Results and Discussion

Variance analysis was performed on the quality characteristics obtained in 20 genotypes examined and the differences between genotypes for all the characters were found statistically significant. The significance groups among the mean values examined were made by Tukey test and the obtained values were given separately. The mean values and the significance groups for crude protein, raw ash and crude oil contents are given in Table 1.

The crude oil in the triticale, barley, wheat, oat and rye cultivars varied between 1.16-1.71%. The highest crude oil was obtained in Harman barley variety with 1.171%, followed by Zenit durum wheat variety and Barberousse barley variety. Bolayır barley variety, Lord barley variety and NKU Ziraat Durum wheat variety were ranked after these genotypes in terms of fat ratio. The lowest crude oil was obtained in the oat variety Kahraman, followed by the Gelibolu bread wheat variety in the same statistic group. Sebat oat variety, Esperia bread wheat variety and Selimiye bread wheat variety are listed later. The crude fat content and the tritical genotypes were in the middle order. The triticale genotypes were in the middle order due to the crude oil content.

When genotypes were examined for crude ash content, this value varied between 1.52-2.27%. The highest amount of crude ash was obtained in Martı barley and Kırklar oat variety with 2.70%, followed by Kahraman oat variety in the same statistic group. Sebat oat variety, Bolayır barley variety and Sladoran barley variety were later included. The Karma 2000, Presto 2000 triticale and Pedujevo rye varieties were in the middle group in terms of crude ash content.

Starch content in the genotypes of the different species examined varied between 44.20% and 59.88% (Table 2). The highest starch was obtained in Gelibolu bread wheat variety. Selimiye bread wheat and Kızıltan 91 durum wheat varieties have the same statistic in this variety. Esperia bread wheat, Aslım rye and NKU Ziraat durum wheat, Presto 2000 triticale, Karma 2000 triticale and Pedujevo rye varieties were listed later. The lowest starch content was obtained in Kırklar oat varieties with 44.20%, followed by Sebat and Kahraman oat varieties. Bolayır and Lord barley varieties are listed later. The obtained data show that Triticale and bread wheat genotypes are superior in terms of starch ratio whereas barley varieties have low starch content.

The difference between the genotypes examined in terms of raw cellulose was found statistically significant and the cellulose ratio varied from 2.57 to 8.02 %. The lowest raw cellulose was found in Selimiye bread wheat variety, followed by Gelibolu bread wheat variety, NKÜ Ziraat and Kızıltan 91 durum wheat varieties. The highest crude cellulose was found in the Sebat oat variety, followed by the oat varieties of Kırklar and Kahraman, barley varieties of Barberousse and Martı. The values obtained indicate that the ratio of crude cellulose is lower in bread wheat varieties. Triticale genotypes were in the middle in terms of these characteristics. The moisture content of grains varied between 10.67-12,60% in varieties. There are no values that vary in quality attributes that affect this feature.

The NDF ratio in the examined varieties varied between 10.67-12.60%. The highest NDF ratio was 12.60% in Pedujevo rye variety, followed by 95 rye variety and Karma 2000 triticale variety. Gelibolu bread wheat variety, Selimiye bread wheat variety, Harman barley variety, Esperia bread wheat variety and Tatlıcak 97 triticale varieties are listed later. The lowest NDF value was obtained in the range Kırklar oat variety, followed by variety of Sebat oat, barley varieties of Bolayır and Barberousse (Table 3).

The obtained data show that the three triticale varieties were in the first order in terms of NDF content. The obtained data show that the triticale variety is very suitable for NDF value which is an important criterion of animal nutrition. On the contrary, these values are found to be the lowest in barley and oat. The difference between the mean values obtained from the ADF content was statistically significant. The highest ADF ratio was found in the Harman barley variety, followed by Esperia bread wheat variety, Martı barley variety, Sebat and Kırklar oat varieties.

The lowest ADF was found in Aslım rye variety, followed by NKU Ziraat and Zenit durum wheat varieties, Gelibolu bread wheat variety, Karma 2000 triticale variety, Tatlıcak 97 triticale variety, Kızıltan 91 durum wheat variety and Presto 2000 triticale variety. Triticale genotypes showed the most suitable characteristics with durum wheat cultivars due to the low NDF ratio required for animal feeding.

ADL content in 20 varieties examined showed a wide variation between 0.83-2.83%. The highest ADL was found in Selimiye bread wheat variety with 2.83%, followed by Pedujevo rye variety, Kızıltan 91 durum wheat variety, Sladoran, Barberousse and Bolayır barley varieties The lowest ADL rates were found in the NKU Ziraat durum wheat variety, followed by Lord barley variety, Zenit durum wheat variety, Heroic oat variety, Martı barley variety, Presto 2000, Tatlıcak 97 and Karma 2000 triticale. The data obtained indicate that the triticale genotypes are suitable for feeding with low ADL values.

Conclusion

The contents of crude protein, crude oil, crude cellulose, starch, NDF, ADF and ADL contents which are important for animal feeding in triticale, bread wheat, durum wheat, barley, rye and oat varieties in the study were investigated.

According to the obtained data, the varieties of durum wheat, barley and triticale in terms of protein ratio, barley and oat varieties in terms of raw ash content, bread and durum wheat varieties in terms of starch ratio, rye and tritical varieties in terms of raw cellulose ratio, bread and durum wheat in varieties in durum wheat, triticale genotypes, Triticale, bread wheat and rye varieties in terms of NDF ratio, varieties of ADF durum wheat, rye and triticale genotypes, ADL ratio in bread wheat, triticale and durum wheat genotypes were found to be most suitable.

When the quality characteristics examined are evaluated, triticale is the most suitable species together with bread wheat in terms of animal feeding quality compared to alternative grains. The considering abiotic stress factors, disease and pest, triticale is the most suitable species for animal feeding.

Table 1. Mean values and significance groups for protein, ash and fat ratio.

Genotypes	Protein (%)	Genotypes	Oil (%)	Genotypes	Ash (%)
13	15.35 a	16	1.710 0	19	2.27 a
6	15.30 a	13	1.710 a	17	2.27 a
15	15.30 a	14	1.710 a	11	2.24 a
16	14.40 b	15	1.660 b	20	2.17 ab
12	14.25 c	18	1.660 b	15	2.10 ab
5	14.05 d	6	1.660 b	10	2.05 ab
8	14.05 d	1	1.615 c	16	2.05 ab
18	14.00 e	4	1.615 c	14	2.03 ab
4	13.90 e	5	1.613 c	18	2.03 ab
2	13.50 f	19	1.612 c	7	1.83 ab
10	13.10 f	8	1.610 c	1	1.82 ab
14	12.60 g	10	1.610 c	4	1.78 ab
9	12.55 h	7	1.560 d	8	1.78 ab
19	12.55 h	12	1.560 d	6	1.70 ab
3	12.50 g	9	1.520 e	5	1.68 ab
11	12.00 ı	2	1.520 e	2	1.67 ab
7	11.55 j	20	1.460 f	9	1.67 ab
1	11.35 k	3	1.430 fg	3	1.62 ab
17	10.60 l	11	1.410 g	12	1.60 ab
20	10.02 m	17	1.160 h	13	1.52 b

Table 2. Mean values and significance groups for starch, cellulose and moisture content.

Genotypes	Starch (%)	Genotypes	Cellulose (%)	Genotypes	Moisture (%)
3	59.88 a	20	8.02 a	7	12.60 a
9	59.78 a	17	7.88 a	1	12.33 ab
5	58.87 a	11	6.47 b	4	12.23 b
2	58.85 b	14	5.07 c	3	12.18 b
1	58.65 b	19	5.05 c	9	12.17 b
6	58.10 c	15	4.95 cd	16	12.12 b
8	57.97 cd	18	4.83 de	2	12.12 b
12	57.88 cd	10	4.77 de	12	12.10 b
4	57.80 cd	16	4.75 e	8	12.07 bc
7	57.77 de	7	2.86 f	11	11.78 cd
13	57.48 e	13	2.81 f	13	11.77 d
10	50.25 f	4	2.77 fg	18	11.72 d
14	50.13 f	1	2.73 fgh	10	11.70 d
19	49.63 g	8	2.72 fgh	5	11.63 de
18	49.58 gh	12	2.71 fgh	19	11.55 def
15	49.28 h	2	2.69 fgh	6	11.50 def
16	48.75 ı	5	2.67 fgh	14	11.40 efg
11	46.73 j	6	2.67 fgh	15	11.30 fg
20	45.58 k	3	2.58 gh	20	11.13 g
17	44.20 l	9	2.57 h	17	10.67 h

Table 3. Mean values and significance groups for NDF, ADF, and ADL properties.

Genotypes	NDF	Genotypes	ADF	Genotypes	ADL
7	12.60 a	16	9.32 a	9	2.83 a
1	12.33 ab	2	7.86 b	7	2.45 b
4	12.23 b	19	6.79 c	5	2.23 c
3	12.18 b	20	6.70 c	2	1.92 d
9	12.17 b	17	6.70 c	10	1.91 d
16	12.12 b	9	6.34 d	15	1.83 e
2	12.12 b	10	6.29 de	14	1.81 e
12	12.10 b	14	6.15 de	20	1.75 f
8	12.07 bc	15	6.08 e	17	1.73 g
11	11.78 cd	11	5.85 f	1	1.65 h
13	11.77 d	18	5.70 fg	3	1.62 ı
18	11.72 d	7	5.59 g	16	1.52 j
10	11.70 d	8	5.51 gh	4	1.49 k
5	11.63 de	5	5.34 hı	12	1.48 k
9	11.55 def	12	5.19 ıj	8	1.30 l
6	11.50 def	4	5.12 j	19	1.30 l
14	11.40 efg	3	4.79 k	11	1.10 m
15	11.30 fg	13	4.20 l	13	1.03 n
20	11.13 g	6	4.05 l	18	0.99 o
17	10.67 h	1	3.80 m	6	0.83 p

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Effect of Application of Increasing Nitrogen Rates on Tillering Characters of Triticale (x*Triticosecale* Wittmack) Genotypes

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ABSTRACT

Grain yield of wheat depends on plants per area, tiller per plant, kernels per spike, and weight per kernel. However only some tillers produce grain; other fail to develop a spike and die before the main stem matures and this is related to genetic factors and other environmental conditions. This research is aimed to determination of effect on different nitrogen applications to ear characters and kernel protein contents of tillers by using six different triticale genotypes (Tatlıcak 97, Melez-2001, MIKHAM-2002, Karma 2000, Samur Sorti, Presto 2000). In this experiment, differences for tillers were observed in triticale genotypes where nitrogen doses were applied during growing period of the year 2006/2007. Considering the effects of nitrogen doses for tillers, while importance of the length of ear is 5%, kernels in ear, weight of kernel, the number of ear was found 1% important. When characterization of kernel examined, 80 kg nitrogen ha^{-1} application on yield and thickness of kernel and protein content was found important by 1%, but the same application on width, length and thousand weight of kernel was found unimportant.

Keywords: ear, nitrogen, protein, spike, tillering, triticale

Introduction

Rapid population growth and drought have made it compulsory to obtain abundant and quality crops in order to feed the world's population adequately (Anonymous 2018). Scientists are also working on cereals, which are the most planted and produced plant group in the world to serve this purpose. With the increase in population, the inadequacy of agricultural areas has led to the need to develop plants that will lead to high yields from the difficult conditions of crops production. In particular, the development of biology, the effective use of genetic and plant regeneration methods have enabled good results to be obtained from these studies. One of the most successful products obtained from these studies was triticale (Anonymous 2017).

The plants need nitrogen at every stage of their development. There are two growing periods in the uptake of nitrogen from cereals, one of tillering stage and the other for spike formation stage (Alzueta et al. 2012; Wang et al. 2017). Tillering is an important feature in terms of grains and is particularly useful for compensating properties when faced with bad conditions (such as anomalies in emergence, winter or frost damage) (Dreccer et al. 2013). Since the bud plant, which will be formed by the first tiller, is formed with three leaves, in order to be supported from the beginning of the tillering, the nitrogen must be present in this period when it can be taken by the plant. If there is nitrogen deficiency during the formation of the 4th and 5th leaves on the main stem of the plant, it will be too late to support the formation of the first two tillers even after application of nitrogen after 6th leaf formation. In such a case, even if the third tiller is formed, the first and second tillers with high efficiency potency may disappear. On the contrary, if there is nitrogen deficiency after the formation of the first 2nd or 3th of tillers, the plant may consist only of the main stem and these tillers, even if water and other environmental conditions are more favourable for tillering may remain ineffective (Reichenberger 2006). This research is aimed to determine the effects of increasing variations in nitrogen doses, triticale genotypes and lines on the tillering traits and the characteristics of spike and grain, which determine the yield potential depending on the environmental conditions, and to determine the effects of the differences between the varieties and the tillers on the yield.

Materials and Methods

Experimental Site and Soil Properties

The research was carried out in the research field of the Eskisehir Osmangazi University Faculty of Agriculture in the center of Eskisehir in 2006/2007 year. The results of soil analysis taken from 0-30 cm depth to determine the physical and chemical properties of the study site are given in Table 1. Soil had low organic matter, alkaline and moderate lime. The available phosphorus and potassium were inadequate and adequate, respectively. The soils contained insufficient Zn, Mn (10.3 mg kg^{-1}) and sufficient Cu (1.27 mg kg^{-1}) but high Fe (4.55 mg kg^{-1}) concentrations. The soil texture was loam and the soils had low in total nitrogen supply to plants.

Climate Data and Experimental design

The average annual precipitation and temperature (from October to July) is 347 mm and 9.1°C for the area over the last 60 year, 301 mm and 9.2°C for 2006/07. In both years, the total precipitation was less than the average of many years (346.9 mm). The average temperature was higher in the second year (9.2°C) than in the first year (8.5°C). The average relative humidity was close to each other in both years.

The five triticale varieties (Tatlıcak-97, Karma 2000, Melez-2001, MIKHAM-2002 and Presto) which are registered as winter triticale varieties in Turkey, an Azerbaijan variety (Samur sortu) and five lines obtained from CIMMYT was used in the study. Characteristics of triticale genotypes in the experiment are given in Table 2.

The 11 hexaploid winter triticale genotypes were provided from Bahri Dagdas International Agricultural Research. The sowing was done in October (10th in 2006). Each plot (7.5 m^2) was six rows and the space between the row s was 25 cm. The seeds were planted with 450 seed m^{-2}. The 60 kg P_2O_5 ha^{-1} as triple superphosphate was applied to all plots. The experimental design was a split-plot design with four replicates. The main plots consisted of four nitrogen levels and the subplots consisted of triticale genotypes. Control plots received no nitrogen (0kg), while nitrogen fertilized plots were treated with 40, 80 and 160 kg nitrogen ha^{-1}. It was applied one-half of nitrogen fertilizer at planting as ammonium sulphate (26% N) and the rest of nitrogen was applied as topdressing at tillering time using ammonium nitrate (33% N). The plants were harvested in July (9th in 2007).

Sampling, measurements and statistical analysis

At harvest time, when the plants were completely dried, they were cut from aboveground in the middle of each plot (3 m x 1 m). The characters of spike length (cm), spikelet number per spike, number of grains per spike, spike weight (g) and protein (%) were determined on 25 randomly selected plants from each plot for each tillers. Protein content of grain was converted from total nitrogen determined using by the Kjeldahl digestion method.

The data were analysed by using MSTAT-C (MSTAT, 1984) the statistical package. The differences between the treatment means were compared by least significant differences (LSD) test.

Results and Discussion

Spike length (cm)

Spike length is important in terms of forming the number of spikelet's in the spike, being highly influenced by environmental conditions. Nitrogen application was found significant ($P<0.01$), for its effect on spike length of tillers and there were differences among genotypes (Table 3). When the averages of spike length of the triticale genotypes were examined; nitrogen application did not increase the spike length.

The control had the highest spike length (9.66 cm) but the lowest spike length (9.18 cm) was at 80 kg N ha^{-1}. The highest spike length of the first tiller was

TVD-9 line (11.43 cm at 80 kg N ha^{-1}) and Samur Sortu genotype (10.35 cm) had the highest spike length at second tiller. The mean spike lengths of the first and second tiller were 9.67 and 9.20 cm, respectively. Spike length differed according to genotypes and nitrogen rates.

Increased nitrogen doses did not increase the spike length of the triticale genotypes and increased the spike length of the first tiller by 4.80% compared to the second tiller. Şekeroğlu (1997) and Gülmezoglu (2003) stated that spike length is between 5.96-6.48 cm and 11.71-11.82 cm respectively, and that with increasing nitrogen doses, triticale increases spike lengths.

Spikelet Number Per Spike

When the variance analysis of spikelet number are examined, the nitrogen was found to be nonsignificant, while the genotype, N x G interaction, tiller, N x T interactions, G x T interactions and N x G x T interaction were found to be significant (Table 4). Nitrogen rates were effective in decreasing the number of spikelet until the application of 40 kg N ha^{-1} in spikelet number per spike of tillers, while it increased at 80 kg N ha^{-1} rate. The highest spikelet number of the first tiller was obtained between 23.95 at 80 kg N ha^{-1} dose, 22.15 at the lowest 40 kg N ha^{-1} dose. The second tiller had the highest spikelet number in control with 21.10, the lowest number of spikes in 20.46 and 80 kg N ha^{-1}.

The highest spikelet number for the first tiller was found on the TVD-9 (28.63 at 80 kg N ha^{-1}) and the lowest number of spikelet at 80 kg N ha^{-1} in the TVD-25 line (19.60 units). The highest spikelet number for the second tiller was obtained from 160 kg N ha^{-1} in the TVD-9 line (24.54 units) and from 80 kg N ha^{-1} in the TVD-4 line (17 units) with the lowest number of spikelet. Spikelet number is a significant character on yield because it can affect grain number. Increasing nitrogen rates did not increase the number of spikelet in triticale genotypes but increasing the number of spikelet in the first tiller 9.35% compared to the second tiller. In the study performed in the triticale genotypes, the number of spike per spikelet changed between 14-27.2 units (Gill, et al. 1990).

Grain numbers of per spike

According to variance analysis (Table 5), nitrogen application, G, T, N x G, N x T, G x T and N x G x T interactions were found significant ($P<0.01$) on grain number per spike. When the average grain number per spike was examined, the highest grain number per spike was 45.28 from the first tiller in control and the lowest grain number per spike was 27.85 from the second tiller (Table 5). The highest and lowest grain numbers per spike in genotypes were TVD-9 (56.63) from the first tiller at 80 kg N ha^{-1} and Melez-2001 (33.15) at 160 kg N ha^{-1}. In the second tiller, TVD-4 had the highest grain (57.17) at 40 kg N ha^{-1} and Presto had the lowest grain (27.85) at 160 kg N ha^{-1}. Also, grain number per spike of the first tiller (43.45) had higher number of grains than that of second tiller (38.22). A large grain number per spike positively affected both yield and quality of grain. (Yanbeyi, 1997; Khaliq et al. 2004).

Spike weight

It was found that N, G, T, N x G, T, N x T, G x T and N x G x T interactions of single spike yields (Table 6) were significant ($P<0.01$). Spike weight of plants was the highest in control (1.62 g). Increasing nitrogen doses had been found to reduce the yield of single spikes. The highest single spike weight of first tiller was obtained from TVD-4 line (2.55 g) at 40 kg N ha^{-1}, while the lowest single spike yield was obtained from second tiller at 40 kg N ha^{-1} (0.81 g) from Tatlıcak 97. Spike weight is dependent on spike length, grain number per spike and the grain size and is greatly influenced by environmental conditions and cultivation techniques.

The effect of increasing nitrogen doses on spike yield was negative and the highest from single spike was obtained from the control dose. The single spike yield changed between 2.2 and 2.4 g, application of 120 kg ha^{-1} nitrogen dose to triticale is reported the highest spike weight (Üstünalp 2010).

Total Protein Content

Nitrogen application was found to be significant at 5% level and G, T, N x G, N x T, G x T and N x G x T interactions were found to be significant at 1% level (Table 7). When the average nitrogen effects on the protein of the triticale genotypes was examined, the highest protein value (14.10 %) was found at 160 kg N ha^{-1}. The highest and lowest protein values of genotypes were Samur sortu from first tiller at 40 kg ha^{-1} (17.60 %) and Presto from second tiller at 80 kg ha^{-1} (10.40 %), respectively. Protein content increased with increasing nitrogen rate. Protein is a lifelong necessity for both human and animal nutrition.

Nitrogen doses applied caused a change of 4.36% among the tillers in protein content. In both tillers, the highest protein content was reached in the control dose. It has been explained that the protein content of bread wheat and its environmental factors change irregularly in all locations, and the variation in protein ratio is lower than the effect of environmental factors (Rao, et al. 1993).

Conclusion

In this study, the effect of nitrogen dose applied on the effects of spike properties on nitrogen dosing among the first and second tillers of triticale; however, it was determined that the newly developing tillers had lower spike, grain and protein values than the first tiller. Generally, the highest values are obtained from the control application. Genotypes revealed genotypic differences according to nitrogen doses. The results of the study show that the new developing tiller has lower spike, grain and protein values than the first tiller.

Nitrogen rates were significant effect on all spike characteristics without spikelet number. There were significant differences on spike characters on protein between tillers. First tiller had higher value than second tiller in all investigated characters. The highest spike length, spikelet number and grain number of spike in first tillers were obtained from TVD-9 line at the rate of 80 kg N ha^{-1}. Grain yield was highest in TVD-25 line at 80 kg N ha^{-1}.

Table 1. Physical and chemical properties of the soil.

Texture	pH	Total Salt (%)	Organiz Matter (%)	$CaCO_3$ (%)	Available for plants Phosphate (P_2O_5) (kg ha^{-1})	Available for plants Potassium (K_2O) (kg ha^{-1})	Available for plants Zinc (Zn) (mg kg^{-1})
Loam	7.8	0.087	1.27	5.14	20	190.7	0.60

Table 2. Triticale varieties and pedigri of lines.

Varieties	Variety authority, registration year and pedigree
Tatlıcak 97	BDIARI/Konya
Presto	TZARI/Eskisehir
Karma-2000	TZARI/Eskisehir
Melez-2001	BDIARI/Konya
MİKHAM-2002	BDIARI/Konya
Samur Sortu	Azerbaijan Variety
TVD-3	CHD 333 85/VICUNA_4 CTWS92Y2-10FM-1FM-1FM-0FM
TVD-4	CT1731.81/ARMINO_4 CTWS92Y6-2FM-1FM-2FM-0FM
TVD-9	EMS M83.6039/CT583.81//PRESTO CTWW92WM00010S-4WM-1WM-1WM-1WMR-0WM
TVD-17	ERIZO_10*BULL_1-1//SONNI_4-2 CTSS93B00204S-2M-0Y-0Y-0B
TVD-25	STIER_29/FARAS_1//2*JIL96 CTSS93B00617M-C-3Y-0M-0Y-0B-3Y-OB

Table 3. Mean values of triticale genotypes in spike length (cm) at different nitrogen doses.

Tiller	Genotypes	Nitrogen rates (kg ha^{-1})				Mean
		0	40	80	160	
First Tiller	TVD- 3	9,13 n-aa	9,46 f-v	9,15 m-aa	8,78 u-ab	9,1
	TVD- 4	9,40 g-v	9,36 h-w	8,81 u-ab	8,17 ab-ac	8,9
	TVD- 9	10,37 b-f	9,55 v	11,43 a	11,15 a-b	10,6
	TVD- 17	10,09 c-m	8,78 u-ab	8,85 t-ab	9,56 e-v	9,3
	TVD- 25	9,45 f-v	8,93 r-ab	8,38 y-ac	9,11 n-ab	9,0
	Tatlıcak 97	9,43 f-v	9,60 e-v	8,22 aa-ac	9,88 d-r	9,3
	Melez- 2001	10,17 c-k	11,02 a-c	10,29 b-h	9,93 d-p	10,4
	MİKHAM-2002	9,94 d-p	10,06 d-n	9,52 g-v	9,88 d-r	9,9
	Karma 2000	10,06 d-o	9,78 d-t	10,35 b-g	10,25 b-i	10,1
	Samur Sortu	10,21 b-j	10,48 a-e	10,69 a-d	11,36 a	10,7
	Presto- 2000	9,68 e-u	9,78 d-t	8,42 w-ac	8,95 q-ab	9,2
Second Tiller	TVD- 3	9,47 f-v	9,35 h-w	8,65 v-ab	8,73 u-ab	9,1
	TVD- 4	9,97 d-p	9,19 l-z	6,57 a-d	7,69-a-c	8,4
	TVD- 9	9,98 d-p	9,29 j-z	9,07 p-ab	10,00 d-p	9,6
	TVD- 17	8,95 q-ab	8,67 v-ab	8,15-ab-ac	8,65 v-ab	8,6
	TVD- 25	9,42 f-v	9,10 o-ab	8,36 z-ac	8,95 q-ab	9,0
	Tatlıcak 97	9,32 i-z	9,25 k-z	8,87 s-ab	8,73 u-ab	9,0
	Melez- 2001	9,83 d-s	9,88 d-r	10,12 c-l	9,91 d-q	9,9
	MİKHAM- 2002	8,89 s-ab	9,23 k-z	8,97 q-ab	9,30 i-z	9,1
	Karma 2000	9,64 e-u	9,51 g-v	9,25 k-z	9,33 i-y	9,4
	Samur Sortu	9,55 e-v	10,14 c-l	10,35 b-g	10,30 b-h	10,1
	Presto- 2000	9,60 e-v	9,60 e-v	9,52 g-v	7,68 a-d	9,1
Mean	Nitrogen	9,66	9,55	9,18	9,37	
	Tillers	First Tiller: 9,68		Second Tiller: 9,20		
	Genotypes$^{\&}$	9,09 8,64 10,10 8,96 8,96 9,16 10,14 9,47 9,77 10,38 9,15				
LSD	P<0.01**	N: 0,205 G: 0,339 T: 0,144 G x N: 0,678 G x K: 0,479 G x N x T: 0.958				
	P<0.05*	N x T: 0.219				

N: Nitrogen, G: Genotype, T: Tiller**1% significant; *5% significant; $^{\&}$: The averages are given side by side in accordance with the order of the above genotypes.

Table 4. Mean values of triticale genotypes in spikelet number per spike (piece) at different nitrogen doses.

Tiller	Genotypes	Nitrogen rates (kg ha^{-1})				Mean
		0	40	80	160	
First Tiller	TVD- 3	21,94 e-s	22,25 e-q	21,25 h-v	21,17 h-w	21,7
	TVD- 4	22,45 d-p	23,59 d-ı	21,84 f-s	22,38 d-p	22,6
	TVD- 9	23,63 d-h	23,40 d-j	28,63 a	27,05 a-c	25,7
	TVD- 17	23,59 d-ı	22,40 d-p	23,00 d-m	24,54 c-e	23,4
	TVD- 25	22,88 d-m	21,35 g-v	19,60 t-aa	21,88 f-s	21,4
	Tatlıcak 97	20,50 m-y	20,25 n-z	20,00 p-z	22,46 d-p	20,8
	Melez-2001	21,45 g-u	22,46 d-p	22,81 d-n	19,95 p-z	21,7
	MİKHAM- 2002	21,38 g-u	22,67 d-o	27,90 a	23,30 d-k	23,8
	Karma 2000	23,15 d-l	20,56 l-y	28,55 a	24,95 b-d	24,3
	Samur Sortu	22,06 e	22,13 e-r	22,38 d-p	23,88 d-g	22,6
	Presto- 2000	24,08 d-f	22,63 d-o	27,44 a-b	23,35 d-k	24,4
Second Tiller	TVD- 3	21,56 f-t	22,31 e-p	18,50 x-aa	20,75 k-x	20,8
	TVD- 4	22,13 e-r	23,42 d-j	17,00 aa	19,42 s-aa	20,5
	TVD- 9	22,38 p	21,75 f-s	20,58 l-y	24,54 c-e	22,3
	TVD 17	19,88 p-z	21,45 g-u	21,15 h-w	22,63 d-o	21,3
	TVD- 25	22,25 e-q	21,75 f-s	19,00 t-aa	20,05 o-z	20,8
	Tatlıcak 97	22,42 d-p	18,40 x-aa	18,13 y-aa	19,00 t-aa	19,5
	Melez-2001	20,44 m-y	18,90 u-aa	22,35 d-p	20,50 m-y	20,5
	MİKHAM- 2002	17,81 z-aa	18,60 w-aa	21,38 g-u	21,00 ı-x	19,7
	Karma 2000	22,15 e-r	20,81 j-x	23,13 d-l	20,90 j-x	21,7
	Samur Sortu	18,75 v-aa	19,64 q-z	21,95 e-s	20,60 l-y	20,2
	Presto- 2000	22,25 e-s	22,44 d-p	21,94 e-s	18,85 u-aa	21,4
Mean	Nitrogen	21,78	21,51	22,20	21,96	
	Tillers	First Tiller: 22,93		Second Tiller: 20,79		
	Genotypes[&]	21,22 21,53 23,99 22,33 21,10 20,14 21,11 21,75 23,02 21,42 22,87				
LSD	P<0.01**	N: 1,093 G: 0,927 T: 0,395		G x N: 1,854 G x T: 1,311 N x T: 0,790 G x N x T: 2,622		

N: Nitrogen, G: Genotype, T: Tiller ** 1% significant; * 5% significant; [&]: The averages are given side by side in accordance with the order of the above genotypes.

Table 5. Mean values of triticale genotypes in grain number per spike (piece) at different nitrogen doses.

Tiller	Genotypes	Nitrogen rates (kg ha^{-1})				Mean
		0	**40**	**80**	**160**	
First Tiller	TVD- 3	45,31 e-k	42,25 ı-p	43,56 g-n	36,88 u-ac	42,0
	TVD- 4	47,65 c-g	45,92 d-j	49,75 b-d	42,25 ı-p	46,4
	TVD- 9	45,44 d-k	40,65 l-v	56,63 a	47,25 c-g	47,5
	TVD- 17	47,83 c-g	46,55 d-ı	39,88 m-w	48,54 c-f	45,7
	TVD- 25	41,42 k-s	47,90 c-g	38,95 o-y	37,71 r-z	41,5
	Tatlıcak 97	40,56 l-v	37,88 q-z	33,75 z-ah	43,96 g-m	39,0
	Melez-2001	42,80 h-o	42,71 ı-o	40,67 l-v	33,15 aa-ah	39,8
	MİKHAM- 2002	45,94 d-j	41,25 k-t	49,50 b-e-l	39,55 n-x	44,1
	Karma 2000	53,65 a-b	40,25 m-w	46,55 d-ı	47,35 c-g	47,0
	Samur Sortu	41,50 k-s	46,31 d-j	37,81 r-z	44,88 f	42,6
	Presto- 2000	46,00 d-j	44,13 g-m	42,19 j-q	37,00 t-ab	42,3
Second Tiller	TVD- 3	47,19 c-g	40,19 m-w	35,50 x-af	35,25 x-ag	39,5
	TVD- 4	47,63 c-g	57,17 a	32,59 ac-ah	35,38 x-af	43,2
	TVD- 9	51,13 b-c	40,00 m-w	35,50 x-af	37,59 s-z	41,1
	TVD- 17	37,94 p-z	38,95 o-y	36,15 w-ae	41,42 k-s	38,6
	TVD- 25	41,38 k-s	42,05 j-r	30,13 ah-aı	33,75 z-ah	36,8
	Tatlıcak 97	40,25 m-w	31,00 ag-aı	31,94 ae-aı	31,63 af-aı	33,7
	Melez -2001	42,63 ı-o	35,95 w-af	38,9540 o-y	41,96 j-r	39,9
	MİKHAM- 2002	36,50 v-ad	32,40 ad-ah	35,19 y-ag	32,05 ae-aı	34,0
	Karma 2000	47,10 c-h	35,00 y-ag	41,38 k-s	35,45 x-af	39,7
	Samur Sortu	37,19 s-aa	32,74 ab-ah	35,25 x-ag	31,85 ae-aı	34,3
	Presto- 2000	47,13 c-h	42,56 ı-o	40,94 l-u	27,85 aı	39,6
Mean	Nitrogen	44,28	41,08	39,67	38,30	
	Tillers	First Tiller: 43,45		Second Tiller: 38,22		
	Genotypes[&] 40,77 44,79 44,27 42,16 39,16 36,37 39,85 39,05 43,34 38,44 40,97					
LSD	P<0.01**	N: 1,164 G: 1,541- T: 0,657		G x N: 3,082 G x T: 1,649 N x T: 1,314 G x N x T: 4,359		

N: Nitrogen, G: Genotype, T: Tiller ** 1% significant; * 5% significant; &: The averages are given side by side in accordance with the order of the above genotypes.

Table 6. Mean values of triticale genotypes in spike weight (g) at different nitrogen doses

Tiller	Genotypes	Nitrogen rates (kg ha^{-1})				Mean
		0	40	80	160	
First Tiller	TVD- 3	2,05 d-e	1,43 t-z	1,50 q-x	1,33 y-af	1,58
	TVD- 4	1,87 f-g	2,55 a-b	2,27 b-c	1,61 m-r	2,08
	TVD- 9	1,56 o-u	1,55 o-u	2,21 c-d	1,69 h-o	1,75
	TVD -17	1,88 f-g	1,53 p-v	1,36 x-ac	1,56 o-u	1,58
	TVD- 25	1,58 n-t	1,84 f-h	1,62 l-q	1,59 n-s	1,66
	Tatlıcak 97	1,35 y-ad	1,17 ag-ak	1,09 aı-am	1,47 r-y	1,27
	Melez-2001	1,75 g-m	1,68 ı-p	1,66 j-p	1,17 ag-ak	1,57
	MİKHAM-2002	1,87 f-g	1,77 g-k	1,70 h-o	1,25 ab-ah	1,65
	Karma 2000	1,96 e-f	1,56 o-u	1,77 g-k	1,69 h-o	1,75
	Samur Sortu	1,76 g-l	1,56 o-u	1,51 q-w	1,82 f-ı	1,66
	Presto- 2000	1,45 t-z	1,52 q-w	1,70 h-o	1,39 v-ab	1,52
Second Tiller	TVD- 3	1,62 m-r	1,43 t-z	1,33 y-af	1,19 af-ak	1,39
	TVD -4	1,80 g-j	2,66 a	1,19 ae-aj	1,28 aa-ag	1,73
	TVD -9	1,54 p-u	1,45 s-y	1,05 ak-an	1,08 aj-am	1,28
	TVD -17	1,47 r-y	1,26 ab-ah	1,11 ah-al	1,31 z-ag	1,29
	TVD -25	1,56 o-u	1,65 k-q	1,19 af-ak	1,44 t-z	1,46
	Tatlıcak 97	1,25 ab-ah	0,81 ap	0,86 ao-ap	0,97 al-ao	0,97
	Melez -2001	1,72 h-n	1,36 x-ac	1,52 p-w	1,64 k-q	1,56
	MİKHAM- 2002	0,96 am-ao	1,34 y-ae	0,91 an-ap	0,88 ao-ap	1,02
	Karma 2000	1,64 k-q	1,23 ac-aı	1,20 ad-aj	1,24 ab-ah	1,33
	Samur Sortu	1,71 h-n	1,27 aa-ag	1,38 w-ab	1,24 ab-ah	1,40
	Presto -2000	1,42 u-aa	1,75 g-m	1,86 f-g	0,89 ao-ap	1,48
Mean	Nitrogen	1,62	1,56	1,45	1,35	
	Tillers	First Tiller: 1,64		Second Tiller: 1,35		
	Genotypes[&]	1,48 1,90 1,52 1,43 1,56 1,12 1,56 1,33 1,53 1,53 1,50				
LSD	P<0.01**	N: 0,055 G: 0,052 T: 0,022		G x N: 0,105 G x T: 0,074 N x T: 0,045 G x N x T: 0,148		

N: Nitrogen, G: Genotype, T: Tiller ** 1% significant; * 5% significant; [&]: The averages are given side by side in accordance with the order of the above genotypes.

Table 7. Mean values of triticale genotypes in total protein (%) at different nitrogen doses.

Tiller	Genotypes	Nitrogen rates (kg ha^{-1}) 0	40	80	160	Mean
First Tiller	TVD- 3	13,99 e-q	13,96 e-q	13,63 g-s	15,05 c-ı	14,16
	TVD -4	13,99 e-q	13,23 j-u	12,78 n-w	14,69 c-k	13,67
	TVD- 9	13,47 h-u	13,94 f-q	12,13 s-x	14,85 c-j	13,60
	TVD -17	13,05 k-v	14,11 d-p	13,24 j-u	15,16 c-h	13,89
	TVD -25	13,23 j-u	13,11 k-v	13,61 g-s	15,51 b-f	13,87
	Tatlıcak 97	13,60 g-s	14,54 d-m	13,90 f-r	14,39 d-o	14,11
	Melez-2001	16,38 a-c	13,79 f-s	15,77 b-d	14,02 e-q	14,99
	MİKHAM-2002	13,09 k-v	14,36 d-o	13,73 g-s	14,98 c-ı	14,04
	Karma 2000	14,29 d-p	12,21 r-w	12,73 o-w	14,49 d-n	13,43
	Samur Sortu	14,59 d-l	17,60 a	14,59 d-l	15,16 c-h	15,49
	Presto -2000	14,62 d-l	13,12 k-v	13,65 g-s	14,68 c-k	14,02
Second Tiller	TVD- 3	13,72 g-s	14,34 d-p	14,73 c-k	11,45 v-x	13,56
	TVD- 4	14,67 c-k	13,47 h-u	12,09 s-x	11,83 t-x	13,02
	TVD- 9	13,72 g-s	13,54 h-t	12,77 n-w	12,94 l-v	13,24
	TVD -17	13,05 k-v	14,12 d-p	15,07 c-ı	13,98 e-q	14,06
	TVD -25	13,95 f-q	13,04 k	14,16 d-p	14,42 d-o	13,89
	Tatlıcak 97	11,75 u-x	11,09 w-x	12,31 q-w	13,39 ı-u	12,14
	Melez-2001	15,68 b-e	14,14 d-p	12,62 p-w	13,51 h-t	13,99
	MİKHAM-2002	13,04 k-v	14,66 c-l	13,00 k-v	13,70 g-s	13,60
	Karma 2000	14,45 d-o	11,86 t-x	11,46 v-x	13,80 f-s	12,89
	Samur Sortu	14,68 c-k	16,94 a-b	14,95 c-j	15,27 b-g	15,46
	Presto-2000	13,55 g-t	13,72 g-s	10,47 x	12,83 m-v	12,64
Mean	Nitrogen	13,94	13,86	13,34	14,10	
	Tillers	First Tiller: 14,11		Second Tiller: 13,50		
	Genotypes&	13,86 13,34 13,42 13,97		13,88 13,12 14,49 13,82 13,16 15,47 13,33		
LSD	P<0.01**	G: 0,611 T: 0,260 G x N: 1,222		G x T: 0,864 N x T: 0,521 G x N x T: 1,728		
	P<0.05	N: 0,429				

N: Nitrogen, G: Genotype, T: Tiller ** 1% significant; * 5% significant; &: The averages are given side by side in accordance with the order of the above genotypes.

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Some Operating Parameters, Energy Efficiency, Carbon Dioxide Emission and Economic Analysis of Triticale and Wheat Grown in High Altitude Semi-Arid Climate Conditions

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ABSTRACT

Triticale is an important plant in animal nutrition that can be used to close the considerable gap in roughage and concentrated feed in our country. Furthermore, with the developments in recent years it has become possible for triticale to be used as a mixture in the production of human foods as well as used alone. In this study, some operating values, energy usage efficiency, CO_2 emission and gross profit of Umranhanım triticale, which was produced in 2014-2015 and 2016 under rain fed agricultural conditions and registered by East Anatolian Agricultural Research Institute. In addition, comparisons have been made over the same parameters with Doğu-88 wheat which has been grown by our Institute during the same years and conditions as well as registered by our Institute. Accordingly, the highest average fuel consumption in agricultural tools and machinery used in triticale and wheat production was the plow (20.59 l ha^{-1}) followed by the cultivator and harvester. The highest energy input with 43.32% was fertilizer energy, followed by fossil source diesel fuel-oil input with a 41.6% decrease. It has been determined that triticale produced 41.8% more energy than wheat plants and 0.8 MJ energy was consumed to produce 1 kg of triticale while wheat required 77% more energy. A similar situation occurred in energy productivity, 1.2 kg triticale was produced with 1 MJ energy while the amount of wheat produced was 0.7 kg. 33.2% more gross profit was achieved in triticale production compared to wheat.

Keywords**:** triticale, wheat, fuel consumption, energy efficiency, CO_2 emission, economic analysis

Introduction

Triticale is an amphidiploid of wheat and rye hybrid and an artificial cool climate cereal type resistant to cold, drought and diseases (Kaydan and Yağmur 2008). The first significant development regarding triticale was obtained with the hybridization of wheat and rye by Wilson in 1875 (Varughese et al. 1987). The first studies on triticale in our country were initiated with materials provided by CIMMYT in the 1970s. Production permission was obtained for the Bakırçay variety, however the first type of triticale was registered by Bahri Dağdaş International Winter Grain Research Center (Konya) in 1997 under the name of Tatlıcak 97 (Kutlu and Kınacı 2011).

When the data for the past 10 years is evaluated it shows that the world's triticale cultivation areas have increased by 28% to 4.2 million hectares in 2016 from approximately 3.2 million ha in 2002 (FAOSTAT 2018). Among the main countries growing triticale in the world Poland has the highest cultivation area with 1 403 519 ha, followed by Germany with 396 100 ha and France with 334220 ha. When China, Russia, Spain, Hungary and Lithuania are included in this group, 73% of the world's triticale cultivation is carried out by these countries. Turkey started to grow triticale in 2003 and constitutes 0.9% of triticale cultivated in the world with 37621 ha as of 2016.

Triticale, which can be used in arid conditions more efficiently than other cool climate grains, gets resistance to diseases from rye plants and can be grown in areas instead of wheat in areas where wheat production is restricted. (Genç et al. 1988). It is reported that triticale has better ability to utilize soil than grains such as wheat, barley and oats, and is therefore less affected by changing environmental conditions. (Gregory 1974). In fact, triticale is cultivated in acidic soils, high altitudes and stony areas (Barier et al. 1980).

Compared to wheat, it has an economic and environmental advantage with lower input requirements. It is resistant to diseases to a major degree and has high efficiency in low-yielding soils. Because of these properties, it is the most suitable grain plant for the organic farming system (Hackett and Burke 2004).

Wheat is one of the most produced crop plants in the world and is an indispensable cultivar in terms of nutrition, trade and crop rotation systems in many countries. The cultivation areas and production of wheat, which has no alternative in terms of human nutrition, is increasing in parallel with population growth. It is estimated that the per capita wheat consumption in the world was approximately 70 kg in the 1960s and it is now around 100 kg. Average world wheat yield increased to 300 kg da^{-1} in recent years, and as of 2010, the world wheat yield record has been determined as 1564 kg da^{-1}. Turkey can produce about 1/5 of the potential of the existing cultivation areas. Accordingly, the opportunity to increase wheat production by increasing the unit area yield without increasing the existing cultivation areas continues (Anonymous 2011).

Wheat production which was approximately 2.5 million tons in our country in the 1930s increased to 10 million tons in 1967 and to 20.6 million tons in 2009. The wheat production increase rate was 724% during this period. While this increase in production up to a certain period incurred because of the increase in cultivation areas, in the subsequent period improvement works and suitable cultivation techniques made a significant contribution to the increase in production. The yield obtained from a unit area was 92 kg da^{-1} in 1930 and increased by 35.9% in 1967 to 125 kg kg da^{-1}. While the increase in cultivation areas from 1967 to 2010 was 1.0%, the increase in yield was realized as 104.8%. Turkey's population was approximately 13.6 million in 1927 and reached 73.7 million as of 2010. According to this, the rate of increase in the population from 1930 to 2010 was 442%, while the rate of increase in wheat production was 724% which has prevented major bottlenecks in our country in terms of countering the demand for wheat (Anonymous 2011).

The average yield of triticale (376348 da) in Turkey is 332 kg^{-1}, while in the North East Anatolian region (18255 da) yield has decreased by 13.3% to total 288 kg^{-1} and the yield in Erzurum (3804) has decreased by 8.7% to total 303 kg da^{-1} (TUİK 2016).

Fischer (1993) reports that Triticale has a high protein content and a good amino acid balance, which is a better feed quality than wheat and barley.

Triticale is an alternative product for marginal areas and is more resistant to the stress conditions caused by the environment than wheat and barley. Significant improvements in summer and winter yields have been achieved over the years and it has been used as plants or grain to feed cattle and sheep, especially poultry. Because of its poor grinding and cooking qualities the use of Triticale in human food used to be limited, however as a result of the developments achieved in recent years, it can now be used alone as well as mixed with quality wheat flour in different proportions and used in baking cakes, biscuits, bread and making pasta (Bağcı et al. 1999).

Giunta and Motzo (2005) explained that the reason why triticale has a higher yield grain potential than wheat was because of the number of grains per unit area, grain weight and growth rate of each grain and a longer grain filling time.

The average plant height, spike lengths, grain number-yield and unit area yields of wheat, barley and 4 different varieties of triticale were examined in a study carried out under the conditions of Van and the highest values were determined in triticale (87.8cm, 7.8cm, 41.5 units^{-1} 38 g and 303.5 kg da^{-1} respectively) (Yağmur and Kaydan 2007).

The grain yield, dry grass and green grass yield for triticale, bread wheat, durum wheat, rye and oat genotypes in terms of adaptation status has been revealed in a study conducted in the Thrace region. All of the triticale genotypes studied were higher in yield, green grass, and dry grass than durum wheat, barley and oat varieties and the majority showed higher value and adaptation than bread wheat and rye (Başer et al. 2008).

The widespread use of machinery in agriculture, the related increase in the use of inputs and the industrial consumption habits that came with the urbanization has reduced the importance of barley, oats and rye. The world's triticale production area has increased by 99% in the last 20 years (2016) while production has increased 92%. The triticale production area in our country has increased by 27% from 2004 to 2016 while production increased 32% (FAOSTAT 2018).

For sustainable economic development, greenhouse gas emissions need to be on a minimal level. Between 1970 and 2004, CO_2 emissions from fossil fuel use increased by around 80% and global temperature increased by 0.5°C (Nazlı 2017). The agricultural sector contributes significantly to global energy use and greenhouse gas emissions. More agricultural production will be needed to feed the growing world population. Therefore, the negative effects of agriculture on the environment will increase. 9% of the greenhouse gas emissions in 2014 were generated by agricultural production procedures by the agricultural sector throughout the world (Öztürk et al. 2017).

Agricultural land use and vegetation changes account for about 20% of global CO_2 emissions per year. A significant portion of the CO_2 emissions from agricultural activity can be reduced by conservation and reduced agricultural production processes (IPCC 2011).

Frequent droughts, extreme and unexpected rainfall have deteriorated the agricultural systems and balances of many countries to significantly affect their crop production. In addition to these changes in ecology, the increasing world population has caused the resources to decrease rapidly. This has led to a necessity to incur a steady increase especially in the production of cereals as well as the necessity to produce in marginal areas, which has led researchers to identify new product groups and increase unit yields. The first successful study on this issue has been obtained in triticale (Kün 1996).

This study was carried out for 3 years on a high elevation plain in a rain fed semi-arid climate zone with wheat which is the most widely produced plant in the world with no alternative in terms of human nutrition and triticale which is important in animal nutrition and has been used in human nutrition in recent years grown simultaneously and under the same field conditions. Some work achievements, fuel consumption, human labour requirements, energy inputs and fuel-based CO_2 emissions and gross profits of triticale-fallow and wheat-fallow planting executed by traditional method (moldboard plow + cultivator + Combined harrows + sowing + harvesting machine) have been determined and the differences in the values for both plants have been manifested.

Materials and Methods

Trial area

The study was carried out in the trial areas of the Eastern Anatolia Agricultural Research Institute, which is located at an altitude of 1721 m in the Erzurum-Pasinler plain of the Eastern Anatolia Region. The principal soil groups in the trial areas with a flat topographic structure are alluvial and colluvial soil groups . The study region has a semi-arid climate, the summers are short, the winters are cold and snowy. The long year average (2000-2016) of total annual precipitation is 423.5 mm while the average temperature is 6.1°C and average relative humidity is 66.9%.

Agricultural applications

The same equipment was used in soil tillage, sowing, maintenance and harvesting processes (Figure 1) in triticale and wheat production and their properties are given in Table 1. All equipment was towed with a 50 kW tractor with a weight of 3 396 kg and an economic life of 12000 hours. In practice, the parcels were driven at a depth of about 25-30 cm by means of a two-casing reversible mouldboard plow as the primary tillage tool. Subsequently a cultivator which was the secondary tillage tool was used at a depth of 12-15 cm as well as rotating disc harrow was used for seed bed preparation. The seeds of triticale and wheat were sown with a disk harrow with a capacity of 5-6 km h^{-1} in the second week of September with 200 kg per unit area (ha).

Before the planting both plants, chemical analyzes of soil samples taken from the trial areas were carried out and according to the results of the analysis, triple super phosphate (42-45% P_2O_5) ammonium nitrate (33% N) and Urea (46% N) were applied in varying doses.

Operation values

Time measurements of the agricultural tools and machines used in the trial were taken with 1/100 C min double-tap timepiece with the total time study and work phases added time method for actual speed; tractor-mounted speed radar and skidding sensors mounted on the tractor wheel at an angle of 120°. Actual fuel consumption was measured by using; The fuel was measured using a specially designed electronic fuel counter with a precision of 1% placed between the fuel tank and the pistons and between the pump and the fuel tank for recycles (Figure 2). Measured data were converted to significant data in the data storage unit and evaluated according to equations recommended by Özden (1995) and the ZET computer package program.

Energy efficiency

Table 2 shows the energy equivalents of inputs (diesel fuel-oil, human labour, tractor and instrument-machine manufacturing energy, chemical fertilizer, seed) and outputs (yield) to calculate energy output/input values in triticale and wheat production.

The energy efficiency use for triticale and wheat production (soil tillage, sowing, maintenance and harvesting) has been calculated with the help of the equations proposed by Öztürk (2010) as the output/input ratio, specific energy, energy efficiency and net energy efficiency depending on the energy inputs and outputs. Energy inputs are evaluated as direct and indirect in terms of energy usage, and as renewable and non-renewable in terms of energy resources. While human labour, diesel fuel-oil energy was considered as direct energy, machine manufacturing, seed, chemical fertilizer, agricultural drug energy inputs were taken as indirect energy. (Lorzadeh et al. 2011).

Carbon Dioxide Emission

Fuel-based CO_2 and specific carbon dioxide emissions have been calculated by taking into account the fossil fuel and oil consumptions used during the 3 years of triticale and wheat production based on rain fed conventional crop rotation conditions at a high altitude and semi-arid climate zone (Öztürk et al. 2017).

Gross margin analysis

Gross margin analysis for wheat and triticale production was carried out according to Aras 1988. Gross margin was calculated by subtracting the variable costs from the gross production value. Furthermore, variable expense rate and production threshold (yield-price) were calculated with the following formulas in order to compare the results of the production of triticale and wheat.

Results and Discussion

Fuel consumption and operational values

It has been determined in this study that the effective business success and fuel consumption, human and machine labour need values can be correlated with operating parameters. Accordingly, considering the production period of triticale and wheat, negative linear correlations have been determined between the average work performance and fuel consumption (r=0.737), human labour requirement (r=0.759) and machine labour requirement (r=0.719). Similar results have been reported by Leghari et al. (2016) that effective work performance has a negative association with fuel consumption.

The agricultural tools and machinery used in both plant productions were the same and the obtained values which were close to each other were analysed by means of averages. According to this, using 38.2% of the total diesel fuel (20.6 l ha^{-1}) in agricultural equipment used in both plants, the highest CO_2 emissions (59.1 kg CO_2 ha^{-1}), human labour (4.1 h ha^{-1}), machine use (3.8 h ha^{-1}) was obtained from the plow that correspondingly processed the least amount of area (0.264 ha h^{-1}) in the time unit (h). This was followed by the cultivator (19.4 l ha^{-1}) which consumed 49.4% less fuel than the plow. The lowest fuel consumption and fuel based CO_2 emissions on the basis of the agricultural equipment used were determined to be the pulveriser which consumed 94.3% less than the plough (Table 3). In their study Gözübüyük et al. (2001-2011) indicated that they had obtained similar results with traditional soil tillage-planting applications in terms of fuel consumption and some operating parameters.

In the study, an average of 0.11 hectares of land (tillage, sowing, maintenance and harvesting) and 12.7 h of human labor were needed for the tillage, sowing, maintenance and harvesting of triticale and wheat. In addition to the 53.9 liters of diesel fuel consumption, 154.7 kg of CO_2 was released into the atmosphere. 11.57 g CO_2 specific CO_2 emissions were generated for the production of one unit (kg) of triticale, while wheat produced under the same conditions was found to generate 43.3% more specific CO_2 emissions (Table 4).

Grain and straw yields

The three-year average yield of 3.92 kg ha^{-1} for triticale in Erzurum was above the average for Turkey (3:03 to 3:32 ton ha^{-1}) (TSI 2016) which is 26.6% more when compared to the wheat yield (Figure 3). A similar situation was manifested in the straw yield, 33% more straw was obtained from triticale (9.62 ton ha^{-1}) than the wheat plant.

Input-output energy requirements in triticale and wheat

In terms of energy inputs of wheat plants and triticale, the energy input for wheat was 63.7% higher for agricultural pesticide inputs (273 MJ ha^{-1}), 53.3% higher for fertilizer input (6417 MJ ha^{-1}) and 3.5% higher in seed input (2696 MJ ha^{-1}) while in other energy inputs (fuel-oil, human labour and machine manufacturing) wheat had an average of 2.1% less energy input compared to triticale (Figure 4). Chemical fertilizer used for both plants according to the results of soil analysis was the leading and highest energy input followed by fuel-oil and seed input while the lowest input consisted of the human labour input. The rate of input of fertilizer energy in the distribution rates of inputs was 38.4% for triticale, while this rate was 48.3% for wheat (Figure 5). While the wheat fertilizer energy input in this study almost equalled the Turkey average (48.8%) it was more than the rate obtained in a study conducted in the U.S. (21%) (Yaldız et al. 1990; Kumar et al. 2013). The seed input energy in the study was above the average in Turkey with 23.9-20.3% (15.1%) while in developed countries the average was around 7% (Yaldız et al. 1990; Anonymous 1989). The value obtained for tool-machine manufacturing energy input rate at 8.1-6.4% was close to the average in Turkey (6.7%) amounted to half the value for the U.S.A. (Yaldız et al. 1990). While 115028 MJ energy output was obtained for the Triticale plant per unit area in return for an energy input of 10905 MJ, the corresponding output for wheat was 22% more in input and 29% less in energy output (Figure 6).

Energy efficiencies

The main purpose of agricultural production is to obtain optimum yield with minimum cost or to use energy efficiently. The energy ratio, which means the energy efficiency in production which is desired to be high was 10.5 for the triticale plant and 41.8% lower for the wheat plant. In order to produce one unit quantity (kg) of product, 0.8 MJ energy was used for triticale while 77% more (1.4 MJ) energy was used for wheat. In the production of triticale, 1.2 kg of product was obtained for the unit of energy consumed (MJ) while the amount of product from the wheat plant was 43.5% (0.7 kg) less. The triticale from the unit area (ha) generated a net energy output of 104123 MJ, while the net energy output of wheat was less by 34.3% (Figure 7).

Direct (25.6%) and renewable (22.3%) energy inputs on plant basis were found to be quite low In the study, compared to indirect (74.4%) and non-renewable (77.7%) energy inputs (Figure 8). Although better values are obtained from triticale than wheat, it is not proportionally on the desired level. It has been determined that both plants generate mostly limited non-renewable energy inputs which are harmful to the environment are predominant and they are caused by high fertilizer and diesel fuel-oil energy input.

Gross margin

The variable costs per hectare in wheat production amounted to 1148.2 lira, while in triticale production amounted to 1045.7 lira (Table 5). The cost structures of both products are similar and 30.4% of the variable costs in wheat production was fertilizer, 27.9% was seed and 24.1% was fuel costs, while in triticale production 33.6% of the expenses were fertilizer, 26.5% was fuel and 23.9% were seed costs.

While the market prices of products and by-products were close to each other, there were significant differences in terms of yield. In the unit area (ha) wheat had a kernel yield of 2875.2 while triticale yielded 3916.7 kilograms and the by-product yield of wheat was 6444.9 while triticale yielded 9618.3 kilograms. This significant difference in yield is reflected in gross production value and gross profit. In wheat production, the gross profit per hectare is 4604.4 lire while this is 6896.8 lira for triticale production. When the two products are compared proportionally, the variable costs in wheat production constitute 20% of the gross production value, while this rate is 13.2% in triticale production. In other words, 5.01 unit gross income was obtained for one unit cost in wheat production and 7.59 unit gross income was obtained in triticale production. In terms of gross profit value, wheat production generated 4.01 lira in gross profit per unit cost while triticale generated 6.60 lira in gross profit.

Another important criterion to compare wheat and triticale production is to determine the production threshold in terms of yield and price. In other words, it is important to compare the yield and price levels in which both products can be produced or their variable costs can be met. Yield amount on the production threshold of wheat is 1304.8 and triticale is 1307.1 kilogram. Currently, the yield of wheat is 2.2 times the production threshold and the yield of triticale is 3.0 times the production threshold. The price level on the production threshold is 0.40 lira for wheat and 0.27 lira for triticale. In terms of yield and price levels on the production threshold, triticale is more advantageous than wheat. Considering the current yield and price levels, the adverse environmental and climatic conditions that may lead to a yield drop in triticale are lower than that of wheat while it is more resistant to adverse economic conditions that may lead to the manifestation of the market price.

In this study, triticale-fallow rotation system was applied as an alternative to wheat-fallow rotation system applied in dry farming conditions and fuel consumption, some operating values, yield, CO_2 emission and gross profits were determined and compared for both plants in these rotation systems. According to the results obtained;

- Fuel consumption, work performance, human and machine labor needs were close and high values were obtained for the production of both plants. In particular, minimized tilling or no-till systems have become inevitable to reduce the fuel consumption of fossil fuels, carbon dioxide emissions, reduce human and machinery labor and increase the area's work performance and energy efficiency. Thus, changes in non-renewable energy inputs can be reduced.

- As a result of the crop production, it was determined that energy was used more effectively by 41.8% by triticale compared to the wheat plant. The biggest factor that increases energy efficiency and profitability is the amount of product obtained as a result of production. In order to increase these values, it is necessary to increase the seed yield and quality characteristics as well as to reduce the inputs. This requires that necessary importance is given to seed breeding studies and national varieties suitable for ecological conditions should be developed.

- Countries should be encouraged to turn to environmentally friendly and renewable energy sources as a result of greenhouse gas emissions generated by the use of fossil fuels, the threat of global warming throughout the world and gradual depletion of fossil fuel reserves.

Figure 1. Triticale and soil tillage toprak sowing work images.

Table 1. Equipment's and the properties used in production processes of triticale and wheat.

Operation data	Agricultural operations					
	Tillage			Sowing	Spraying	Harvesting
	MP	C	CH	SM	P	CH
Effective width, cm	88.2	194.0	207.8	300	750	130
Depth, cm	25.9	15.4	6.8	5.8	-	-
Weight, kg	440	430	440	372	260	398
Speed, km h^{-1}	2	9	-	21	5.8	-
Economic life, h	2000	2000	2000	1500	1500	2000

MP: Mouldboard Plow, C: Cultivator, , CH: Combined Harrows, SM: Sowing Machine, P: Pulverisator, CH: Combine Harvester

Figure 2. Time study table, fuel gauge, speed radar and data storage unit.

Table 2. Energy equivalents of inputs and output in triticale and wheat production.

Definitions	Unit	Energy equivalents MJ unit-1	References
A. Inputs			
Diesel fuel-oil	l	56.31	Amanloo and Mobtaker, 2012
Human labour	h	2.3	Gözübüyük et al. 2012
Tractor	kg	158.5	Gözbüyük et al. 2012
Agricultural equipment's	kg	121.3	Gözbüyük et al. 2012
Fertilizer (P_2O_5)	kg	12.44	Banaeian and Zangeneh, 2011
Fertilizer (N)	kg	64.14	Banaeian and Zangeneh, 2011
Triticale	kg	13.02	Görgülü M. 2002
Wheat	kg	13.48	Görgülü M. 2002
Herbicide	kg	238	Barut et al. 2011
B. Outputs			
Triticale yield	kg	13.02	Görgülü M. 2002
Wheat yield	kg	13.48	Görgülü M, 2002
Triticale+wheat straw	kg	6.66	Görgülü M. 2002

Table 3. Some operating values of instruments used in triticale and wheat production.

Parameters	MP	C	CH	SM	P	CH
Diesel fuel-oil consumption, l ha^{-1}	20.59	10.42	6.07	5.52	1.18	10.10
Effective field capacity, ha h^{-1}	0.264	0.457	0.809	0.997	3.197	1.053
Human labor need, h ha^{-1}	4.069	2.407	1.332	2.158	0.672	2.041
Machine labor need, h ha^{-1}	3.786	2.240	1.239	1.004	0.313	0.950
CO_2 emissions, kgCO_2 ha^{-1}	59.13	29.91	17.44	15.85	3.39	29.00

MP: Moldboard Plow, C: Cultivator, , CH: Combined Harrows, SM: Sowing Machine, P: Pulverisator, CH: Combine Harvester

Table 4. The operational values of agricultural equipment's used in triticale and wheat production.

Parameters	Triticale	Wheat
Diesel fuel-oil consumption, l ha^{-1}	53.96 ± 0.30	53.80 ± 0.37
Effective field capacity, ha h^{-1}	0.103 ± 0.002	0.107 ± 0.002
Human labor need, h ha^{-1}	12.89 ± 0.22	12.47 ± 0.22
Machine labor need, h ha^{-1}	9.71 ± 0.20	9.36 ± 0.20
CO_2 emissions, $kgCO_2$ ha^{-1}	154.95 ± 0.86	154.49 ± 1.05
Specific CO_2 emissions gCO_2 $kg_{ürün}^{-1}$	11.57 ± 0.62	16.58 ± 0.17

Figure 3. Triticale and wheat grain and straw yield values.

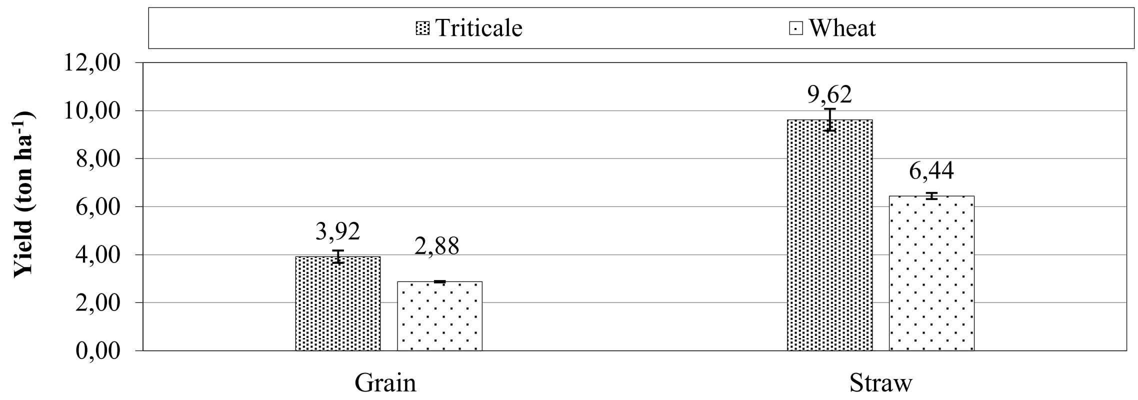


Figure 4. Energy inputs of triticale and wheat production.

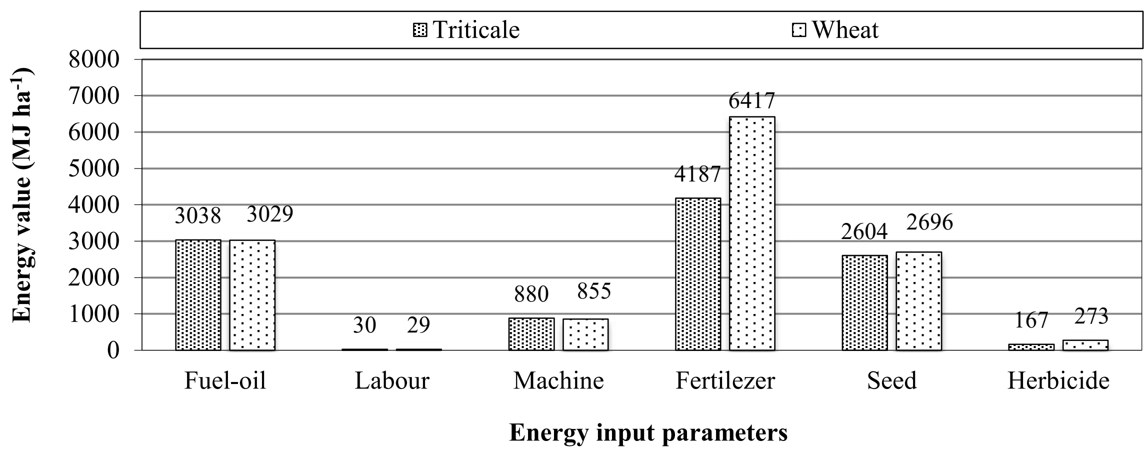


Figure 5. Share of input energies.

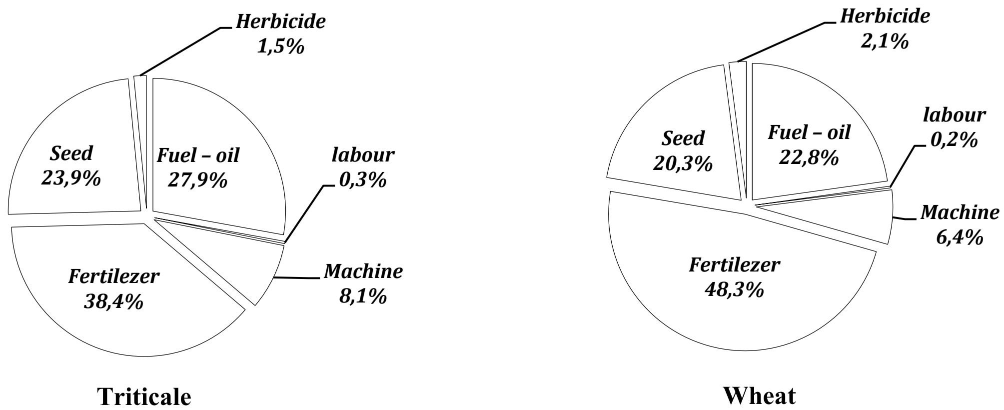


Figure 6. Energy input and output values.

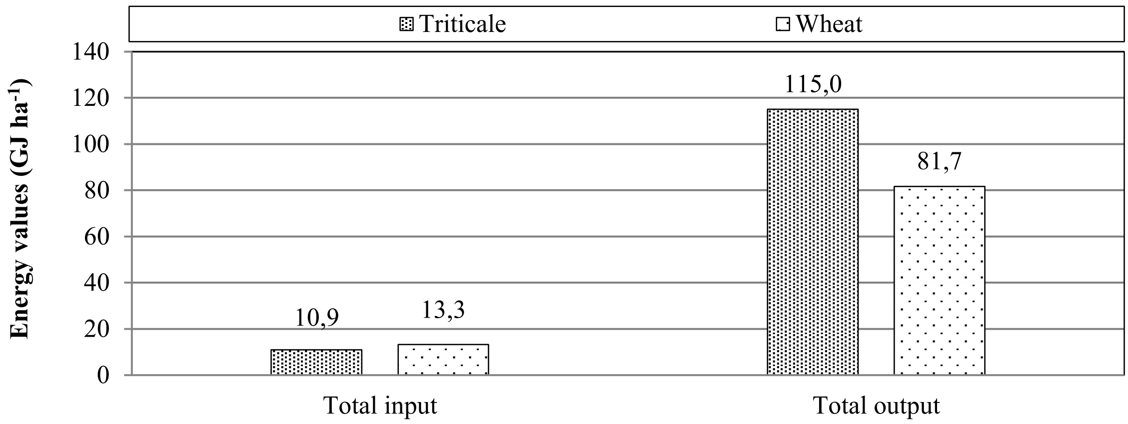
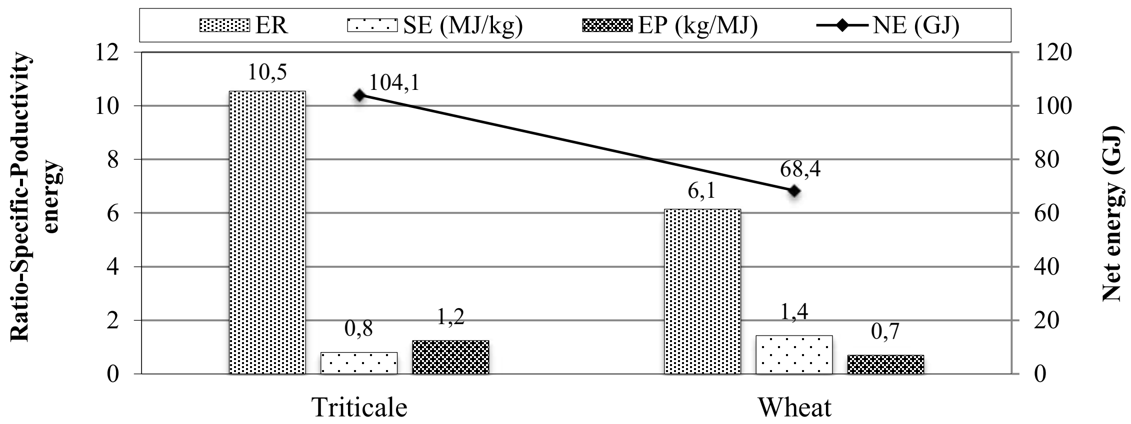
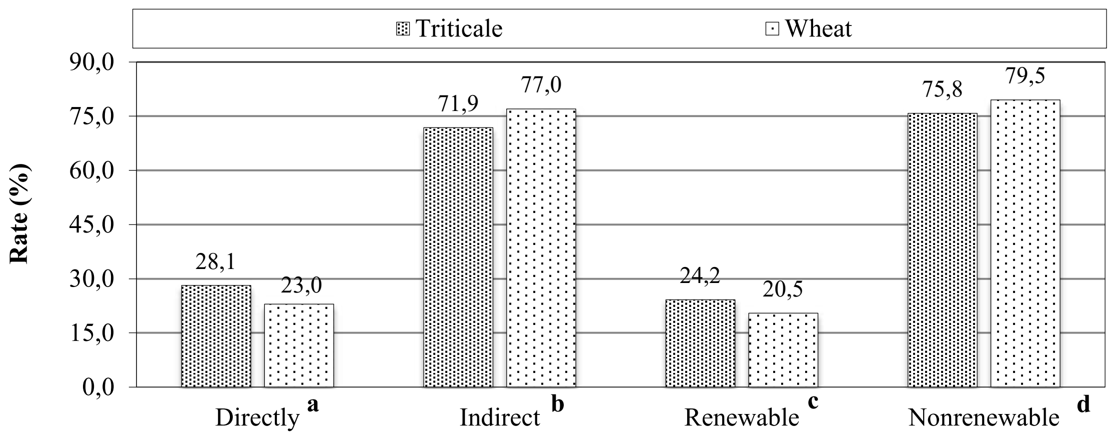


Figure 7. Energy efficiencies of triticale and wheat.



ER: Energy ratio; SE: Specific energy; EP: Energy productivity; NE: Net energy

Figure 8. Direct, indirect, renewable and non-renewable energy.



[a] Human labor, Diesel fuell-oil; [b] Machine manufactoring, Seed, Fertilizer, Herbicide energy
[c] Human labor, Seed; [d] Diesel fuell-oil, Chemical fertilizer, Machine manufactoring, Herbicide energy

Table 5. Costs and gross profits of triticale and wheat production (TL ha^{-1}).

Costs and Income		Triticale	Wheat
Seed		250.0	320.0
Fertiliser		351.7	348.5
Herbicide		21.0	61.0
Human labour		103.1	99.8
Diesel fuel		277.4	276.5
Engine oil		42.5	42.4
Variable Cost		1045.7	1148.2
Yields (kg ha^{-1})	Main products	3916.7	2875.2
	By-products	9618.3	6444.9
Product price	Main products By-products	0.80 0.50	0.88 0.50
GSÜD		7942.5	5752.6
Gross profit		6896.8	4604.4
Changing Cost Ratio (%) (Operating Expense Ratio)		13.2	20.0
Production threshold	Yields (kg ha^{-1}) Costs (TL kg^{-1})	1307.1 0.27	1304.8 0.40

Note: Variable Cost Rate: (Variable Cost / Gross Production Value)x100
Production threshold (Yield) = (Variable Cost / Price)
Production threshold (Price) = (Variable Cost /Yield)

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Review Article

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Prospects of Advanced Genomics for Development of Climate Resilient Wheat Genotypes

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ABSTRACT

Wheat is one the most important cereal crops of the world. As it major crop commodity for food security, there is a need to increase wheat production by developing new high yielding and climate resilient varieties,to meet the projected demand of increasing population and with changing climate. In the present review we have discussed the prospects of the advanced genomics approaches for development of climate resilient wheat genotypes and role of advanced technologies like High-throughput phenotyping, next generation sequencing, genomics-assisted breeding, and CRISPR/Cas9 genome-editing have been emphasized for management of abiotic stressors in wheat.

Keywords: wheat, genomics, abiotic stress, genome editing

Introduction

Crop production is mainly affected by the climate changes hindering the growth and development of the plants due to unfavourable environmental factors, which is the main challenge to the agriculture. Major abiotic stresses to plants include the temperature either heat or cold, drought and salinity, which are causing a huge productivity loss and are the main concern for the agricultural scientists to combat climate change for food security. Plants have intrinsic molecular regulatory mechanisms to develop resilience and tolerance to these abiotic stresses, which are the focus to increase crop productivity. Since the green revolution, the scientists are working on enhancing and engineering plants mechanism against abiotic stresses to increase the productivity(Calanca, 2017; Mosa et al. 2017).

Wheat is the world's third largest cereal crop cultivated in 220.4 million hectare area with the production of 729 million tonnes, with an average yield of 3.3 tonnes/hectare (FAO, 2015).There is a need to increase wheat production by 1.6% annually by 2020 to meet the projected demand of 760 million tons (Calanca, 2017). New high yielding and climate resilient varieties must be developed to improve agricultural production of wheat.The conventional breeding approaches are slow and inaccurate to simultaneously select for and combine putative loci from different genetic backgrounds for such a huge improvement demand. There have been major genomic advancements for the wheat improvement in the recent years as follows.

1. High-throughput phenotyping tools and marker-assisted selection provided a new opportunity for improving the selection efficiency and pyramiding of genes conferring tolerance to abiotic stresses.

2. Recent advances in next generation sequencing have transformed molecular breeding to the genomics-assisted breeding. Functional genomics approaches are identifying genes and/or QTLs responsible for the abiotic stress tolerance in crop species as well as in wild relatives.

3. High-density marker arrays like SNP and InDels etc. from next generation sequencing facilitated the genotyping-by-sequencing; the genome wide association studies and the genomic selection approaches, which are superior to conventional phenotypic selection for discovering novel genes for abiotic stress tolerance.

4. Whole genome sequence assembly revolutionised the field with the genome of the reference hexaploid wheat line ‘Chinese Spring’ with assembled 21 constituent chromosomes. It will be possible to identify target genes, examine their expression pattern across hundreds of RNAseq samples, determine their haplotypes in diversity collections and order knockout mutants using targeted genome editing.

5. This extensive fundamental research of plant stress tolerance could improve commercial crop yields. In wheat, major QTLs have been identified for drought; heat and cold stress; salt tolerance, which will provide novel opportunities for abiotic stress tolerance and for a more targeted search for novel alleles in wild germplasm.

6. There are increasing number of germplasm resources including precise near isogenic lines as well as next-generation populations such as multi-founder populations (e.g., multi-parent advanced generation intercross populations), which have been developed to facilitate validation of climate-smart crops. New variation incorporated into elite backgrounds from landraces, ancestral or wild crop relatives also offers potential for discovery of functional variation.

7. The CRISPR/Cas9 genome-editing technology can be a useful integral component of functional genomics to study the genetic basis of abiotic stress response and/ or tolerance in the large and complex wheat genome by knocking out or silencing target genes or genomic regions. Further transgene free targeted gene editing has been demonstrated in wheat which could generate elite cultivars with durable climate resilience. Enhancing photosynthesis efficiency in wheat through modification of key enzymes (e.g. Rubisco) will be the key to increase wheat yield potential.

Conclusion

The difficult to predict climate impact on crops could be reduced with the advanced genomics technologies, but it requires a multidisciplinary and integrated approach to more effectively accumulate favourable alleles from different backgrounds to develop genotypes that are more resilient to climate change for food security in future.

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Research Article

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Determination of Superior Turkish Eggplant (*Solanum melongena* L.) Genotypes by Pedigree Selection Method

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ABSTRACT

Eggplant (*Solanum melongena* L.), belonging to the *Solanaceae* family, is widely grown in Turkey. It is also one of the important vegetable species in Turkey. Additionally, Turkey has valuable eggplant populations. This study was conducted to select valuable local eggplant genetic resources under the ecological conditions of Samsun province in 2016. In this study, 75 eggplant genotypes were detailed from different eco-geographical regions of Turkey. The weighted ranking method was also used to select superior eggplant genotypes with pedigree selection. It was determined that the total weighted ranking scores of eggplant genotypes studied was in the range of 290-475 point. According to the total weighted ranked scores, 20 promising eggplant genotypes with a score of 420 and above were determined for use in the variety breeding program. At the end of this research, the genotypes G30, G43, G49, G51 and G55 were determined to be superior for further breeding studies.

Keywords: *Solanum melongena*, genetic resources, selection, Turkey

Introduction

The genus *Solanum* shows a wide and rich genotypic variation with more than 1000 species (Fukuoka et al. 2010). The origins of eggplant (*Solanum melongena* L.) in the genus *Solanum* has been reported in the literature as India, Burma, and China (Küçük 2003; Daunay et al. 2001; Tümbilen, 2007). It was brought to the Mediterranean basin and then to Spain first by the Arabs. It was later spread by the Turkish people all over Europe through the Balkan countries (Cakir et al. 2017). It has been reported that eggplants first reached Anatolia in the late 16th and early 17th centuries (Kalloo, 1993; Vural et al. 2000).

Eggplant is an important vegetable crop in Turkey cultivated as a summer vegetable in the open field, while grown in the greenhouses in the winter and spring season. China (32,001,667 tons) and India (12,552,000 tons) are the leading eggplant producers in the World. Turkey is in the fourth place in production in the World with 854,049 tons (FAO, 2016). It is grown in almost every region in Turkey. The regions with the highest eggplant production in Turkey include the Mediterranean Region (406,675 tons), the Southeast Anatolia Region (101,527 tons) and the Aegean Region (98,151 tons) (TUİK, 2016).

Plant genetic resources have an important values and importance in terms of variety breeding studies since they contain the determined cultural plants and their wild relatives (Engels et al. 1995). In addition, local genetic resources, due to their adaptability to different ecologies, their resistance to diseases and pests, and the demanded quality attributes they possess, they are unique sources of breeding activities. Plant breeders have achieved significant success in recent years to select or develop varieties with the desired traits in terms of adaptation, yield, quality, resistance to diseases and pests by utilizing the existing genetic diversity in Turkey. The detailed studies on the collection of local eggplant genetic resources, identification of plant characteristics are fewer compared to other Solanaceae species in Turkey (Çakır, 2018). This show the fact that eggplant breeding studies should be increased.

Turkey has very high phenotypic diversity and genotypic variability in many vegetable species such as eggplant of which it is not their gene centre (Karaağaç and Balkaya, 2017). Morphological variations are of great importance in variety breeding studies. Because, it is very important to know the existing variations in the cultivated species for plant breeding programs (Bliss, 1981).

Selection is the most important factor that changes the structure of a population. Selection reduces or increased some genotypes since it changes the gene frequency in a population. The effect of selection on measurable traits is examined by considering some quantitative parameters (Balkaya et al. 2011). Phenotypic diversity in eggplant populations is very high. The variations are mostly determined by fruit shape, fruit colour, fruit bitterness, fruit flesh thickness, fruit flesh colour, fruit size, prickliness, the number of seeds (Frary et al. 2005; Çakır, 2018).

Local eggplant genetic resources have been collected by many researchers from different geographic regions of Turkey (Filiz and Özçalabı, 1992; Pirinç, 1999; Tümbilen, 2007; Boyacı et al. 2010; Topcu, 2014). However, few studies had been conducted to determine the genotypes suitable for fresh consumption by selection breeding. Kaplan and Koludar (1986) were selected seven eggplant genotypes from local Şeyhkent eggplant population in Diyarbakır province. In another study, Surtepe 1, Surtepe 2, Mezra 5 and Keskince 3 namely eggplant genotypes were selected as suitable eggplant local varieties for fresh consumption from local Şanlıurfa eggplant populations (Pirinç, 1999). In the other selection study conducted on eggplant populations collected from Diyarbakır province, three eggplant genotypes were determined. Among these, the genotype Şeyhkent-3 was reported as eggplant genotype with the highest weighted ranking score (725 point) (Pirinç and Pakyürek, 2004). Boyacı et al. (2010) found that the average fruit weight of the local genotypes, grown with the name of 'Göl Patlıcanı' in Burdur province and it had different types, ranged from 110.3 g to 199.6 g.

The present study comprises the first start-up phase of the eggplant breeding studies for new developing varieties. Accordingly, the aim of this study was to determine the promising eggplant genotypes suitable for fresh consumption in eggplant populations collected from different regions in Turkey by pedigree selection method.

Materials and Methods

Materials: This study used a total of seventy five eggplant seeds collected from different regions of Turkey (Table 1). Forty accessions of the *S. melongena* populations were obtained from the USDA-ARS National Germplasm Bank, twenty accessions of the *S. melongena* populations were provided from the Turkish National Seed Gene Bank (AARI) and fifteen accessions of the *S. melongena* populations were collected by Prof. Dr. Ahmet Balkaya, of the Horticulture Department of the Faculty of Agriculture of Ondokuz Mayıs University (Table 1). The genetic material consisted of landraces and local populations maintained by farmers for generations.

Growth conditions: The field component of this study was carried out in the Samsun province in 2016. The seeds of all populations were sown into plug trays containing peat and perlite (in the ratio 3:1) on April 16, 2016. After the field in which the trial was established was plowed, in the field, cultivation places were prepared. The cultivation places were mulched with mulch; drip irrigation system was set and made ready for seedling planting. Soil tests were carried out before planting. The soil of the experimental area was sandy loam with pH 6.5. Fifteen seedlings from each eggplant genotype was planted at the 4 to 5 true leaf stage at a spacing of 50x50 cm on May 20, 2016. Standard fertilization and weed control practices were applied.

Determination of eggplant genotypes suitable by pedigree selection method: The aim was to determine the eggplant genotypes suitable for fresh consumption with long-cylindrical smooth fruits with black or dark purple color and with little or no seeds in the selection breeding. Accordingly, pedigree selection method was used in variety breeding. The fruit and yield characteristics data were evaluated by the modified weighted ranked (WR) method (Çakır, 2018).

The WR method is a tool commonly used in statistical analyses. This method is known as "Tartılı derecelendirme" in Turkish and almost exclusively used in the studies with multivariate data generated in horticultural research (Balkaya and Yanmaz, 2005; Balkaya and Ergün, 2008). Class values of selection criteria, Class Scores (CS) and Relative Scores (RS) were assigned (Table 2). The total points of types were calculated by summing Class Scores (CS) and multiplied by Relative Scores (RS). Accordingly, genotypes that were above the average score were selected as the promising eggplant genotypes. Otherwise, eggplant genotypes were also classified according to the characteristics examined, and accordingly, the distribution frequencies of genotypes were shown in this study.

Results and Discussion

All local eggplant genotypes were evaluated according to the weighted ranking method. The results of the weighted rankings are given in Table 3. Examining Table 3, local eggplant genotypes were found to have a total score in the range of 290-475 points. Among all the genotypes, the genotype G51 (475 points) determined the highest score. This was followed by G30 (470 points), G43 (470 points), G55 (470 points) and G49 (465 points) genotypes. It was determined that the majority of the eggplant genotypes that received high scores had the highest scores in terms of all the characteristics of the selection. As a result of the evaluations, the lowest value as found in the G25 genotype with 290 points. According to the results of weighted rankings, it was found that 37 eggplant genotypes had a total score of Promising genotypes which found a score between 420 and 475 were selected for the second-year study.

In terms of average fruit length, it was found that 63 of the local eggplant genotypes had long, 8 genotype had medium-sized, and 4 genotype (G42, G62, G65, G60) had very long fruits (Table 3). According to the demands of consumers and producers, long eggplant fruits are preferred for fresh consumption in Turkey. In this study, in terms of frequency distribution, 84% of the local eggplant genotypes had long fruits which is important in terms of the selection of many eggplant genotypes suitable for fresh consumption. In another study carried out by Topçu (2014), of the 100 eggplant genotypes collected from different regions of Turkey, 32 had long fruit sized while 31 had medium-sized, 15 had short, 4 had oval, 8 had pear-like and 10 had round fruit shapes. The research results were shown similar with this literature.

The fruit diameters of the majority of eggplant genotypes varied between 50 mm and 100 mm. In terms of fruit diameter values, 65.3% of genotypes were found to be medium-sized and 26.7% were large sized (Table 3). In terms of fruit colours, the eggplants were divided into different groups as purple (20 genotypes), reddish (10 genotypes), black (16 genotypes), green (13 genotypes) and light purple/lilac (16 genotypes) (Table 3). Filiz and Özçalabı (1992) were mentioned that on the phonological, morphological and pomological characteristics of some local eggplant varieties in Turkey, fruit skin colour ranged from green and yellow to dark purple and black. These results showed that the eggplant gene pool is heterogeneous and the level of variation is high in terms of fruit shape and fruit colours.

The sepal size in eggplant fruits is a very important criterion in terms of storing ability (Çetinkaya et al. 2009). In terms of the sepal size, 32 of the eggplant genotypes were found to be medium-sized, 38 genotypes were small-sized and 5 genotypes (G5, G14, G15, G29, G50) were very small-sized (Table 3). In sepals, prickliness was either absent or almost absent in 51 eggplant genotypes. The selected genotypes G35, G43, G51, G52, G55 and G56 had no prickliness in their sepals. This trait is a desired trait for the development of new eggplant varieties by the breeders.

It was determined that there were great differences between the eggplant genotypes in terms of yield components. In addition to the role of multi-gene inheritance in yield, this explains the fact that the types are quite different from each other. Comparing the eggplant genotypes, it was determined that four genotypes (G18, G23, G27, G44) had average fruit weights less than 150 g. However, it was found that there were 59 genotypes with fruit weights in the range of 150-300 g and 12 genotypes with fruit weights higher than 300 g (Table 3). It was determined that difference between the lowest and the highest yield values were approximately two-fold. High yield are more preferred in eggplant cultivation. Of the selected eggplant genotypes, 53.3% had low yield per plant values, 38.6% had moderate yield per plant values and 8.1% had very high yield per plant values. The majority of the selected genotypes were found to be superior in terms of yield components. The other remain genotypes are considered to be evaluated in the other breeding studies. As a result, G30, G43, G49, G51 and G55 genotypes were found to have higher yield values than other genotypes (Table 4). These superior genotypes are planned to be re-evaluated in terms of yield components in different environmental conditions.

Conclusion

In this study, pedigree selection method was carried out in the eggplant population collected from different locations in Turkey. The evaluations were made according to the weighted ranking method. It was determined that the eggplant genotypes have a total score between 290 and 475 point. According to the selection scores, a total of 20 eggplant genotypes with a score of 420 point and above were selected for using in the eggplant variety breeding program. At the end of this study, G30, G43, G49, G51 and G55 determined as superior genotypes. It will be possible to evaluate the different frequency distributions of the fruit characteristics of the eggplant genotypes collected from different locations in Turkey according to their breeding purposes. In the future, these studies are planned to continue to obtain new hybrid eggplant varieties in Turkey. In addition, this study provides a general overview of the status of present in morphological variation at gene pools. Thus, detailed information on the morphological variability between local eggplant genotypes was obtained.

Table 1. Code, accession number and collected sites of *Solanum melongena* in Turkey.

Code	Accession Number	Collected Sites	Code	Accession Number	Collected Sites
G1	PI 166994 01	Hatay/USDA	G39	PI 204630 01	Kayseri
G2	PI 167381 01	Adana/USDA	G40	PI 204731 01	Kayseri
G3	PI 169642 01	Aydın/USDA	G41	TR 61766	Muğla
G4	PI 169644 01	Muğla	G42	TR 55995	Trabzon
G5	PI 169649 01	İzmir	G43	TR 70757	Samsun
G6	PI 169658 01	Kırklareli	G44	TR 70758	Samsun
G7	PI 169667 01	Kocaeli	G45	TR 70756	Amasya
G8	PI 171850 01	Kastamonu	G46	TR 69835	Çorum
G9	PI 171851 01	Samsun	G47	TR 70768	Kastamonu
G10	PI 171853 01	Tokat	G48	TR 70767	Kastamonu
G11	PI 173104 01	Artvin	G49	TR 70766	Sinop
G12	PI 173106 01	Ağrı	G50	TR 68531	Bartın
G13	PI 173111 01	Kahramanmaraş	G51	TR 68532	Bartın
G14	PI 174359 01	Van	G52	TR 68528	Zonguldak
G15	PI 174360 01	Diyarbakır	G53	TR 55678	Giresun
G16	PI 174362 01	Mardin	G54	TR 77307	Edirne
G17	PI 174369 01	Gaziantep	G55	TR 69211	Antalya
G18	PI 174371 01	Gaziantep	G56	TR 75349	Artvin
G19	PI 174373 01	Malatya	G57	TR 70764	Sinop
G20	PI 174374 01	Elazığ	G58	TR 70765	Sinop
G21	PI 175909 01	Balıkesir	G59	TR 75345	Artvin
G22	PI 175913 01	Çorum	G60	TR 70759	Samsun
G23	PI 175914 01	Yozgat	G61	OMU-ZF/BAH	Aydın
G24	PI 175916 01	Kayseri	G62	OMU-ZF/BAH	Aydın
G25	PI 176758 01	Niğde	G63	OMU-ZF/BAH	Manisa, Salihli
G26	PI 176760 01	Konya	G64	OMU-ZF/BAH	Aydın, İncirliova
G27	PI 176761 01	Konya	G65	OMU-ZF/BAH	Aydın
G28	PI 176762 01	Bilecik	G66	OMU-ZF/BAH	Kemer
G29	PI 176763 01	Eskişehir	G67	OMU-ZF/BAH	İzmir, Bayındır
G30	PI 177073 01	Çanakkale	G68	OMU-ZF/BAH	Aydın
G31	PI 177074 01	Kayseri	G69	OMU-ZF/BAH	Diyarbakır
G32	PI 177076 01	Konya	G70	OMU-ZF/BAH	Hatay,Samandağ
G33	PI 179045 01	Tekirdağ	G71	OMU-ZF/BAH	Aydın, Nazilli
G34	PI 179496 01	Bursa	G72	OMU-ZF/BAH	Şanlıurfa, Birecik
G35	PI 179498 01	İstanbul	G73	OMU-ZF/BAH	Mersin, Mut
G36	PI 182299 01	Muş	G74	OMU-ZF/BAH	Bursa
G37	PI 182300 01	Kahramanmaraş	G75	OMU-ZF/BAH	Mersin, Mut
G38	PI 183718 01	Kahramanmaraş	-	-	-

Table 2. Weighted Ranking criteria examined in pedigree selection of eggplant genotypes.

Selection Criteria	Classes	Class Score (CS)	Relative Score (RS)
Fruit length (cm)	very short (<10 cm)	1	10
	short (11-15 cm)	2	
	intermediate (16-20 cm)	4	
	long (21-25 cm)	5	
	very long (>26 cm)	3	
Fruit diameter (mm)	very small (<10 mm)	1	10
	small (11-30 mm)	2	
	intermediate (31-50 mm)	5	
	large (51-100 mm)	3	
	very large (>100 mm)	2	
Fruit colour	white	1	5
	black	3	
	purple	5	
	reddish	3	
	light purple/lilac	4	
	green	1	
Fruit colour homogeneity	homogeneous	5	5
	mottled	3	
	striped	2	
Fruit colour tones	light	1	5
	intermediate	3	
	dark	5	
Size of the calyx	very small	1	5
	small	3	
	İntermediate	5	
	large	2	
	very large	2	
Maturing period (day)	early (<60)	4	10
	mid-season (60-75)	5	
	late season (>75)	2	
Seed number per fruit (unit)	No seed	1	10
	Little	5	
	More	3	
Prickliness	None	5	5
	Weak	4	
	Intermediate	3	
	Powerful	2	
	Very powerful	1	
Average fruit weight (g/plant)	<150 g	2	15
	150-300 g	5	
	>300 g	4	
Total yield per plant (g/plant)	Little<480	2	20
	Intermediate 480-945	5	
	Much>945	4	

Table 3. Frequency distribution of the fruit characteristics examined in the eggplant genotypes.

Traits	Class ranges	Frequency ratio (%)
Fruit length (cm)	intermediate long very long	10.7 84.0 5.3
Fruit diameter (mm)	small intermediate big	8.0 65.3 26.7
Fruit colour	purple reddish black light purple/lilac green	26.7 13.3 21.3 21.3 17.4
Fruit colour homogeneity	homogeneous mottled striped	64.0 34.7 1.3
Fruit colour tones	dark intermediate light	52.0 26.7 21.3
Size of the calyx	very small small intermediate	6.7 50.7 42.6
Maturing period (day)	early mid-season late season	26.7 42.7 30.6
Seed number per fruit (unit)	little more	20.0 80.0
Prickliness	none or less little intermediate powerful	68.0 21.3 6.7 4.0
Average fruit weight (g/plant)	<150 g 150-300 g >300 g	5.3 78.7 16.0
Total yield per plant (g/plant)	little intermediate much	53.3 38.7 8.0

Table 4. The total score of eggplant genotypes with relative scores x class scores for each trait.

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G1	50	30	15	25	25	25	20	30	25	60	40	345
G2	50	30	5	15	15	25	20	30	25	60	80	355
G3	50	50	15	15	15	25	50	30	25	60	80	415
G4	50	50	15	25	25	25	40	30	25	75	80	440
G5	50	30	15	25	25	5	40	50	25	60	100	415
G6	50	40	15	25	25	20	30	40	20	75	80	415
G7	50	50	20	15	15	25	50	30	20	75	80	430
G8	50	50	25	25	25	25	40	30	20	75	80	445
G9	50	50	15	25	15	15	40	30	15	75	40	370
G10	50	50	20	15	15	15	50	30	25	75	40	385
G11	50	50	5	15	15	15	20	30	25	75	40	340
G12	50	50	5	15	5	15	50	30	25	75	80	400
G13	50	30	25	25	25	15	50	30	15	60	80	405
G14	50	50	15	15	25	5	20	30	25	75	40	350
G15	50	50	25	25	25	5	20	30	25	75	40	370
G16	50	30	5	25	15	15	50	30	25	75	80	400
G17	50	50	20	15	5	15	20	30	25	75	40	345
G18	40	50	20	25	5	15	50	30	10	30	40	315
G19	50	30	25	25	25	15	20	50	20	75	40	375
G20	50	50	15	25	25	15	50	30	25	75	40	400
G21	50	50	20	25	15	15	50	30	25	75	80	435
G22	50	50	20	25	5	15	20	30	25	75	40	355
G23	50	50	5	15	15	15	20	30	20	30	40	290
G24	50	50	15	25	15	25	20	30	20	75	40	365
G25	40	50	20	25	5	15	50	30	20	75	40	370
G26	40	50	25	25	25	25	50	30	10	75	60	415
G27	40	50	5	15	5	15	50	30	25	30	40	305

Continuing table 4

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G28	50	50	5	15	5	15	50	30	25	75	80	400
G29	50	30	5	15	25	5	40	30	25	75	80	380
G30	50	50	25	25	25	25	40	30	25	75	100	470
G31	40	30	5	15	5	15	40	30	25	75	80	360
G32	50	50	20	15	15	15	50	30	10	75	80	410
G33	50	30	15	25	25	15	50	30	20	75	40	375
G34	50	30	15	25	15	25	20	50	25	75	40	370
G35	50	30	25	25	25	15	40	30	25	60	100	425
G36	50	50	20	25	25	15	50	30	25	75	80	445
G37	50	30	5	25	5	15	50	30	15	75	80	380
G38	40	30	20	10	5	15	20	30	25	75	40	410
G39	50	30	25	15	25	15	50	30	20	60	80	400
G40	40	50	15	15	25	10	50	30	25	75	80	415
G41	50	20	15	15	15	25	50	30	25	75	40	360
G42	30	50	25	25	25	15	50	30	25	75	40	390
G43	50	50	25	25	25	25	40	50	25	75	80	470
G44	50	20	5	15	5	15	50	50	25	30	40	305
G45	50	50	20	25	15	15	50	30	25	75	40	395
G46	50	30	15	25	25	15	20	30	25	60	40	335
G47	50	50	20	15	15	15	50	30	25	75	40	385
G48	50	50	20	25	15	25	40	30	15	75	80	425
G49	50	50	25	25	25	25	40	30	20	75	100	465
G50	50	50	5	15	5	5	50	30	20	75	40	345
G51	50	50	25	25	25	25	50	30	20	75	100	475

Continuing table 4

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G52	50	50	20	15	5	15	40	30	25	75	100	425
G53	50	20	20	15	5	15	50	30	25	75	40	345
G54	50	50	20	10	15	25	40	30	20	75	80	415
G55	50	50	25	25	25	25	40	50	25	75	80	470
G56	50	50	25	25	25	25	40	30	25	75	80	450
G57	50	50	15	25	25	25	50	50	25	75	40	430
G58	50	50	25	25	25	25	50	30	25	75	40	420
G59	50	50	25	25	25	25	50	30	25	75	40	420
G60	50	50	25	25	25	25	40	50	25	75	40	430
G61	40	30	20	15	15	15	20	50	20	60	80	365
G62	30	20	25	25	25	25	50	30	25	75	40	370
G63	50	50	5	15	5	25	20	50	20	75	40	355
G64	50	50	25	25	25	25	50	50	25	75	40	440
G65	30	20	25	25	25	25	20	30	25	75	40	340
G66	50	50	15	25	25	15	40	30	20	75	80	425
G67	40	30	25	25	25	15	50	30	15	75	80	410
G68	50	30	15	15	15	15	20	50	25	60	40	335
G69	30	20	15	25	25	25	20	50	25	75	40	350
G70	50	50	15	25	25	15	20	30	25	75	40	370
G71	50	50	15	25	25	25	20	50	25	75	40	405
G72	50	30	15	25	25	25	20	30	25	60	80	385
G73	50	30	15	25	25	15	50	30	25	60	80	405
G74	50	50	15	15	5	15	20	30	25	75	40	340
G75	50	50	15	15	15	25	20	30	20	75	40	355

***A:** The average fruit length (cm), ***B:** The average fruit diameter (mm), ***C:** Fruit colour, ***D:** Fruit color homogeneity, ***E:** Fruit color tones, ***F:** Sepal size, ***G:** Ripening period, ***H:** Number of seeds in fruit, ***I:** Prickliness, ***J:** Average fruit weight (g/plant), ***K:** Total yield per plant (g/plant)

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Journal article:

Toker C (1998). Adaptation of kabuli chickpeas (*Cicer arietinum* L.) to the low and high lands in the West Mediterranean region of Turkey. Turk J Field Crop 3:10-15.

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Article by Digital Object Identifier (DOI) number:

Yasar M, Ceylan FO, Ikten C and Toker C (2013). Comparison of expressivity and penetrance of the double podding trait and yield components based on reciprocal crosses of kabuli and desi chickpeas (*Cicer arietinum* L.). Euphyticadoi:10.1007/s001090000086

Book:

Toker C (2014). Yemeklik Baklagiller. BISAB, Ankara.

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Toker C, Lluch C, Tejera NA, Serraj R and Siddique KHM (2007) Abiotic stresses. In: Chickpea Breeding and Management, Yadav SS, Redden B, Chen W and Sharma B (eds.),CAB Int. Wallingford, pp: 474-496.

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Yasar M (2012). Penetrance and expressivity of double podding characteristic in chickpea (*Cicer arietinum* L.). Dissertation, Akdeniz University, Antalya.

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