JOURNAL OF AGRICULTURAL PRODUCTION

https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

Determination of Yield, and Cold Hardiness of Some Triticale (x*Triticosecale* Wittmack) Genotypes in Eastern Anatolia Region

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ARTICLE INFO

Article History:
Received: 20.06.2021
Accepted: 29.06.2021
Available Online: 29.06.2021

Keywords:
Cold hardiness
Eastern Anatolia Region
Triticale
Yield

ABSTRACT

Triticale (x*Triticosecale* Wittmack) is a grain used in animal feed and is known for its high efficiency, high nutritional quality and resistance to stress factors. Triticale is an alternative plant used for the utilization of marginal areas due to these properties. This study was carried out at three different locations in Erzincan and Muş province and Pasinler districts of Erzurum province. Two candidate line and registered triticale varieties (Umranhanım) and 22 triticale lines in the advanced breeding stage were assessed comparatively in terms of efficiency yield and cold resistance parameters. According to the results of this study, Candidate-2 and Line (1, 6, 8, 11, 15, 17, and 18) genotypes were the prominent genotypes in terms of yield. In addition, low precipitation in May and June caused serious losses in yield. Because this period is the pollination period for grains in the Eastern Anatolia Region. Additional irrigation may be recommended in years when precipitation in this period is insufficient. In addition, it has been concluded that it is important to include cold test studies in breeding programs in regions where winter damage is experienced intensively as well as included in the selections.

Please cite this paper as follows:

Küçüközdemir, Ü., Dumlu, B., Karagöz, H., & Yılmaz, O. (2021). Determination of yield, and cold hardiness of some triticale (x*Triticosecale* Wittmack) genotypes in Eastern Anatolia Region. *Journal of Agricultural Production*, 2(1), 26-31. https://doi.org/10.29329/agripro.2021.344.4

Introduction

Genetically, triticale (x*Triticosecale* Wittmack) is a cool climate cereal type obtained by hybridizing wheat and rye. Triticale can generate more yield than wheat, especially in barren regions where soil depth is not suitable for wheat cultivation and winters are severe (Küçüközdemir et al., 2019).

12.80 million tons were produced in an area of 3.81 million hectares in the world. The countries with the highest triticale production are respectively; France, Germany, Belarus, China, Lithuania, Hungary, Austria, Czech Republic, Romania and Serbia (FAOSTAT, 2019). In Turkey, a total of 215.1 tons of triticale was produced from an area of 64.1 thousand hectares, and the average yield is 336 kg/da (TSI, 2019).

In the evaluation of marginal areas, it is stated that Triticale is the priority plant that is capable to increase the cultivation areas and production significantly with the development of new varieties (Müntzing, 1989; Mergoum et al., 1992; Kun, 1996).

Due to limitations in intensive agriculture and possible climatic changes, it will not be easy to increase the production to the extent that it will feed the growing world population. Therefore, the aim is to grow plant species which are more efficient in marginal soils. These plant species should be able to produce high yields with low inputs in marginal or low yield areas. Although, triticale is a newly cultivated plant species, it is rapidly spreading to various production systems (Pfeiffer, 1994).

Soil conditions such as drought, pH level, salinity, lack of trace elements, and toxicity are factors limiting grain yield. Triticale is an advantageous plant in such conditions compared

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to commonly grown cereals. Triticale is an alternative crop to other cereals, especially wheat and barley (Benbelkacem, 1998; Maças et al., 1998; Royo & Aragay, 1998).

Due to the above-mentioned characteristics, it is considered that triticale is an important alternative crop plant in Eastern Anatolia Region, especially in areas where wheat yield is low and unused barren land available for utilization. Therefore, it is important that triticale varieties which are suitable for the ecological conditions of the region and have high efficiency and yield stability are developed and offered to farmers. However, in addition to the genetic yield potential of a variety, the environmental conditions in which the plants are grown are also influence the yield. Under such circumstances, the stability of yield in various environmental conditions is of great importance. Therefore, it is necessary to determine that which genotypes have a stable yield under different environmental conditions. The aim of this study was to determine high efficiency, winter hardiness and high-quality genotypes that could be grown in Erzurum and similar ecological conditions.

Materials and Methods

The trial was carried out for one year during 2019-20 in the trial areas in Erzurum, Pasinler district and Erzincan and Muş province under dry conditions. Two candidate line, Umranhanım types and 22 triticale lines were used in the study. Umranhanım variety used in the study is a winter, medium early, medium-tall (100-120 cm) variety. It is cold and drought resistant.

The winter season trial was established in two different locations in the "Chance Connected Full Blocks" trial design with three replications (Yıldız & Bircan, 1991). Treatments were distributed to the parcels according to chance (Little & Hills, 1978; Yıldız & Bircan, 1991; Mead et al., 1994). Each parcel consisted of 6 plant rows of 6 m in length with 20 cm spacing, and the area of a parcel was 7.2 m^2 (6 m length x 1.2 m width).

Since there is no recommended date for planting triticale, the planting for the trial was carried out between the dates of September 1 and October 1 which is the most suitable date for planting winter wheat (Özcan & Acar, 1990). The seeds were sown with row spacing 20 cm apart at a depth of 4-6 cm and 475 seeds per m^2 with a seed drill. Ammonium nitrate (26%) was used as a nitrogen fertilizer source. Half of the nitrogen fertilizer was applied during sowing and the half during bolting at a rate of 6 kg N and 6 kg P_2O_5 per decare while the phosphor fertilizer was all applied with the planting (Kıral & Özcan, 1990; Akkaya, 1993). Weed control was carried out during the tillering period in rainless and windless weather using the 2,4-D herbicide at a rate of 200 cc/da (Özcan, 1994).

When the wheat reached at harvestable maturity, 50 cm was cut off from each parcel as edge effect and the remaining parts were harvested and blended with a parcel harvester. (Kıral & Özcan, 1990; Akkaya, 1993). Cold test studies were carried out according to the method used by Küçüközdemir et al. (2020). Plants were tested at three different cold temperatures (-17, -19, and -21). In this study, LD50, which is the degree to which more than 50% of a population died, was used to determine the degree of cold hardiness.

Statistical Analysis

The data were determined according to analysis of variance using SPSS 10.0 software package and when the medium was determined, Duncan's Multiple Range Test was used.

Results and Discussion

In the study conducted with 25 triticale genotypes, significant statistical differences were found among the yield of the examined genotypes in all locations and between all locations. The mean values of yield and the statistical groups of the factors according to these averages (P<0.01) was given in Table 1.

Table 1. Yield of location and genotypes (kg/da)

Genotypes	Erzincan**	Pasinler**	Mus**	Mean**
Candidate-1	217.0 a	395.0 ab	301.3 gh	304.4 D-G
Candidate-2	185.3 de	355.0 a-c	499.0 a-c	346.4 A-D
Umranhanım	217.0 a	398.3 ab	493.7 a-c	336.3 A-E
Line-1	194.3 c-e	414.7 ab	503.7 a	370.9 A
Line-2	159.0 g	374.3 a-c	392.0 c-g	308.4 C-G
Line-3	205.0 bc	352.3 a-c	399.0 a-g	318.8 B-G
Line-4	186.0 de	344.0 a-c	331.7 f-h	287.2 E-G
Line-5	130.7 h	347.3 a-c	395.0 b-g	291.0 E-G
Line-6	183.0 d-f	431.7 a	424.0 a-f	346.2 A-D
Line-7	177.0 ef	300.3 bc	418.7 a-f	298.7 D-G
Line-8	212.3 ab	363.0 a-c	502.0 ab	359.1 A-C
Line-9	183.0 d-f	272.3 c	466.7 a-d	307.3 C-G
Line-10	183.3 d-f	353.3 a-c	363.3 d-h	300.0 D-G

(continues on the next page)

Table 1 continued

Genotypes	Erzincan**	Pasinler**	Mus**	Mean**
Line-11	166.7 fg	399.7 ab	507.3 a	357.9 A-C
Line-12	125.7 h	355.7 a-c	447.0 a-d	309.4 C-G
Line-13	133.3 h	398.0 ab	328.3 f-h	286.6 E-G
Line-14	183.0 d-f	361.0 a-c	334.0 e-h	292.7 E-G
Line-15	190.0 c-e	371.0 a-c	439.7 a-e	333.6 A-E
Line-16	190.7 c-e	361.3 a-c	403.3 a-g	318.4 B-G
Line-17	224.3 a	361.7 a-c	506.0 a	364.0 AB
Line-18	155.0 g	369.3 a-c	446.0 a-d	323.4 A-F
Line-19	193.7 c-d	369.0 a-c	276.0 h	279.6 FG
Line-20	180.0 ef	301.3 a-c	328.3 f-h	269.9 G
Line-21	201.0 b-d	316.0 bc	411.7 a-f	309.6 C-G
Line-22	201.0 b-d	345.7 a-c	316.3 f-h	287.7 E-G
Mean	183.1 C	360.5 B	405.4 A	316.3

According to the Duncan test, the averages shown with the same letter are not important in their group ($p<0.05$).

On the basis of locations, the highest yield was determined in Mus location (405.4 kg/da). This location was followed by Pasinler location (360.5 kg/da). The lowest yield was measured in Erzincan location (183.1kg/da). The reason for the low yield in the Erzincan location is the low precipitation during the flowering period, which coincides with May and June (Figure 1). Low precipitation during the flowering period caused insufficient pollination. In other locations, precipitation and temperatures remained within seasonal normal. As a result, higher yields were obtained in Pasinler and Mus locations (Table 1).

The average of the genotypes in the study was determined as 316.3 kg/da. The highest average yield was determined in Line-1 (370.9 kg/da) genotype. Candidate-2, Umranhanım variety, Line-6, Line-8, Line-11, Line-15, Line-17, and Line-18 were statistically in the same group with the maximum group. On the contrary, the lowest average yield was measured as 269.9 kg/da in Line-20 genotype.

Yields in Erzincan location varied between 125-217 kg/da according to genotypes. The highest yields were measured in Umranhanım cultivar and Candidate-1 genotype, which are known to be drought tolerant. In this location, low precipitation in May and June caused yield loss (Figure 1). However, it was observed that genotypes that were more tolerant than other genotypes were relatively less affected by stress factors.

In Pasinler location, as the highest yield was measured 431.7 kg/da, the lowest yield was determined as 272.3 kg/da. Line-1, Line-11, Line-13, and Candidate-1 genotypes and Umranhanım cultivar are other prominent genotypes in this location (Table 1). Precipitation and temperatures at seasonal normal in this location positively affected plant growth (Figure 2). Especially the rains during the flowering period encouraged the formation of grains.

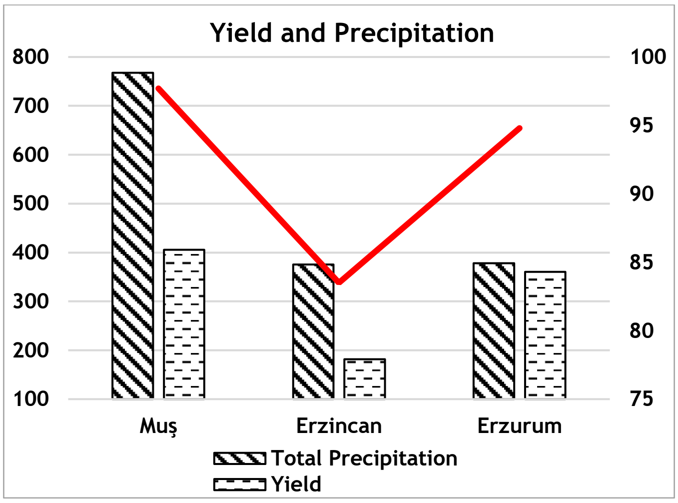

Figure 1. Yield and precipitation.

In the Mus location, where the highest yields were obtained in the study, the yields varied between 507.3-276 kg/da. Line-1, Line-11, and Line-17 were the genotypes with the highest yield in the study. Also, Umranhanım variety, Candidate-2, and Line 8 genotypes were other prominent genotypes (Table 1).

Similar to our work, Küçüközdemir (2016) carried out a study under Erzurum conditions for 10 years with 4 triticale and 3 wheat varieties to obtain the highest and stable grain yield of 418.9 kg/da with Umranhanım. Another study on triticale in Erzurum's arid conditions, the total yield was between 219.9-466.6 kg/da and the differences between the Triticale genotypes were considered significant (Küçüközdemir et al., 2018). In another study, the yield of triticale was determined as 137 kg/da in Erzincan location and 414 kg/da in Erzurum location (Küçüközdemir et al., 2019).

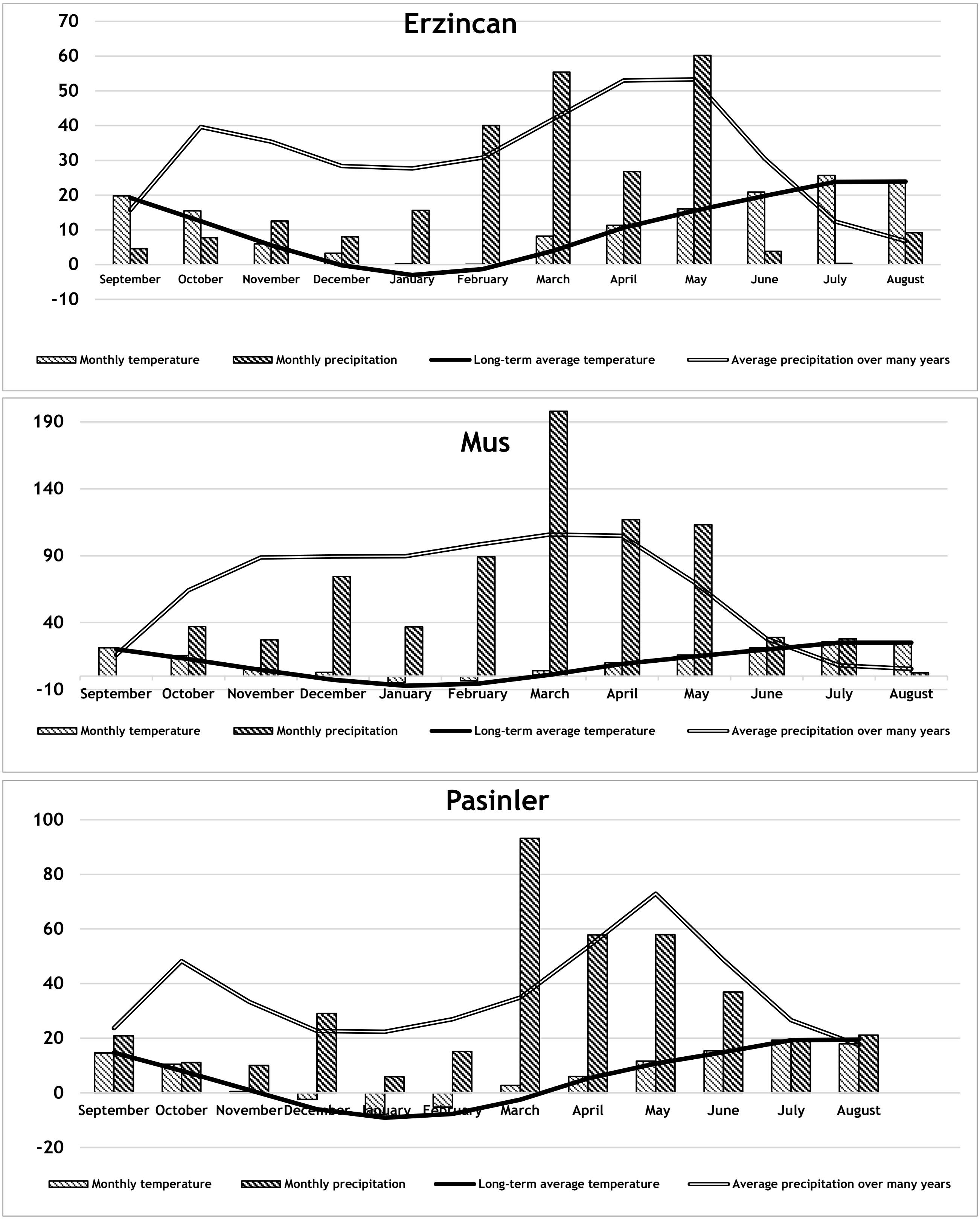

Figure 2. Climate data of locations.

Cold Hardiness

Plants do not only struggle with drought stress in the natural process. Especially in high altitude regions, cold damage causes serious yield losses. The most effective way to combat cold damage is to develop new varieties that are resistant to cold. In this study, cold resistance degrees of triticale genotypes were determined under controlled conditions. According to the test results, it was observed that the genotypes were viable 98.5% at minus 17 degrees, 94.1% at minus 19 degrees, and 75.7% at minus 21 degrees (Figure 3). The reason why viability values are so high is that these genotypes have been selected for cold resistance for many years. In a study on triticale, winter varieties were found to be more than 85% cold hardiness in -21 degrees (Küçüközdemir et al., 2019). In another study on bread wheat (*Triticum aestivum* L.) that another type of grain known as the parent of triticale, it was determined that some bread wheat lines were more than 60% cold hardiness in -21 degrees (Küçüközdemir et al., 2020). In another cold resistance study on bread wheat, cold hardiness was found to be 67 percent in -21 degrees (Karagöz et al., 2020). This situation changed according to plant species and genotypes. Because triticale is the most resistant to cold among cereals (Küçüközdemir et al., 2019).

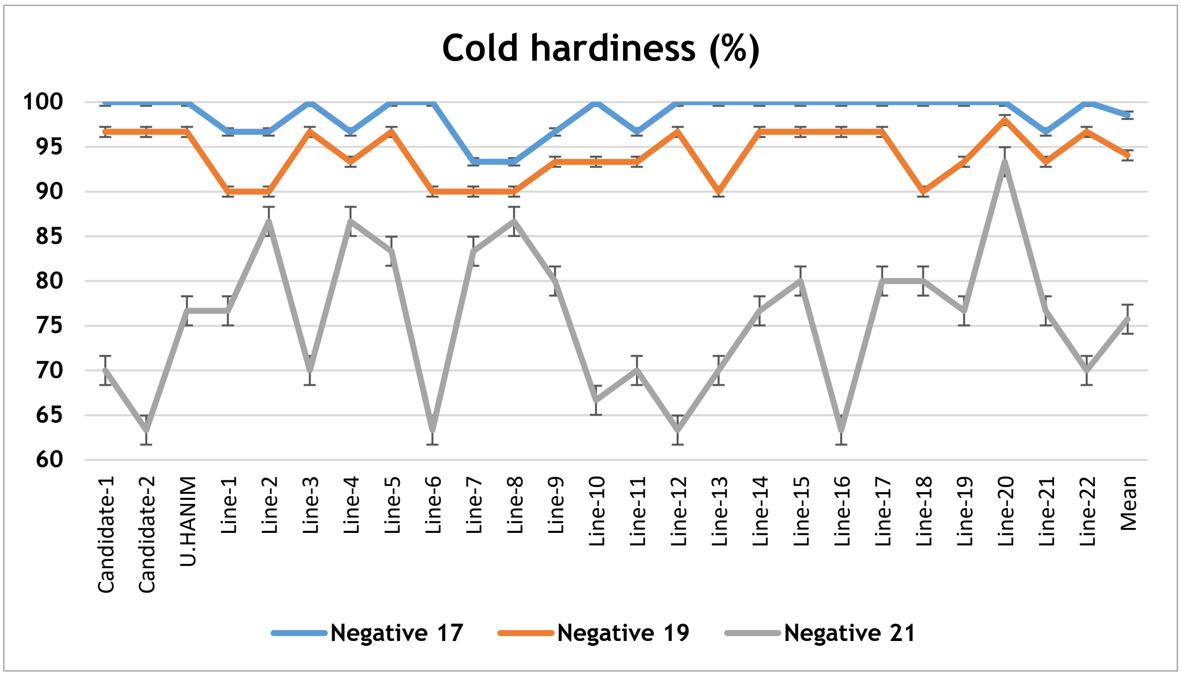

Figure 3. Cold hardiness test.

Conclusion

This study was conducted with three different locations and 25 different genotypes. According to the results of this study, Candidate-2 and Line (1, 6, 8, 11, 15, 17, and 18) genotypes were the prominent genotypes fin terms of yield. In addition, low precipitation in May and June caused serious losses in yield. Because this period is the pollination period for grains in the Eastern Anatolia Region. Additional irrigation may be recommended in years when precipitation in this period is insufficient. In addition, it is a very important that cold resistance observations are included in the breeding programs in regions such as East Anatolia with severe winters and high risk of frost to avoid producers in the region from being affected by winter damage and have a more efficient production. Also, cold resistance studies should be a breeding selection criterion in cold climates such as the Eastern Anatolia region. It is very important to cold hardiness varieties in cold climates for a more stable production. The absolute way to achieve this is the need to develop cold-hardiness varieties.

Conflict of Interest

The authors declare that they have no conflict of interest.

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