Determination of the Yield Quality and Winter Durability Characteristics of Some Bread Wheat (Triticum aestivum) Genotypes in Pasinler and Erzincan Locations

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ABSTRACT

Bread wheat is the most important plant species used in human nutrition and most of the daily protein and calorie needs of people are met from this plant. 13 advanced bread wheat lines, 1 candidate for registration and 6 bread wheat varieties have been compared in terms of yield, number of spikes per square meter, 1000 grain weight, hectoliter weight, plant height, protein ratio, zeleny sedimentation value and 3 different (-17, -19 and -21 °C) cold level parameters in this study. Durable genotypes were determined according to the LT50 value (the degree when 50% of the plants perish with cold stress). As a result of the observations, it was noted that lines 1, 2, 3, 4, 5, 8 were superior in terms of resistance to cold and line 10 displayed superiority in terms of yield compared to the other varieties. It is concluded that these lines may be suitable variety candidates for wheat cultivation in the region. Furthermore, it has been concluded that it is important to include cold test studies in breeding programs in regions like the East Anatolia Region where harsh winters prevail.

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Introduction

Wheat is the leading cultivated plant that in the World as well as Turkey to counter food needs and is a strategically important cereal species (Nohutcu, 2018). Wheat, one of the most grown cereals in the world, is an important food source in human nutrition (Hossain et al., 2018). Wheat ranks second after corn in terms of total production amount (FAO, 2016). Most of the daily protein and calorie requirements of humans worldwide are supplied by wheat grains (Shiferaw et al., 2013). In recent years, wheat demand has increased in parallel with the increase in human population. Therefore, wheat production has a strategic importance in terms of world economy and food security. As a matter of fact, in 2017, 21 million tons of wheat was produced from 76 million decares of land and the average yield was 280 kg da⁻¹ (Anonymous, 2018). Wheat has supplied approximately 20% of the calories consumed daily by the world's population as the main energy and protein source of people for thousands of years (Braun et al., 2010). Wheat ranks first among cultivated crops in agriculture for reasons such as the range of its adaptation limit, mechanization, ease of transport, storage and processing (Kılıc et al., 2012). Grain yield in wheat is genetically influenced by many cultivation techniques and climate factors as well as the yield potential of the variety. Knowledge of the relationship between the various characters in the breeding programs to increase grain yield contributes to the correct orientation of the program as well as selection (Goksoy et al., 2002). In order to be effective on the foreign market, we need to increase our competitiveness by producing...
high quality. Bread wheat breeding works endeavor to improve quality and develop varieties with high yield, that are resistant to diseases and pests and are compatible with environmental conditions.

In addition, one of the important factors that limit plant breeding is low temperature. Morphological and physiological deterioration occurs in plants that are subjected to low temperatures depending on the duration of exposure. The development of cold resistant varieties is very important as this situation causes great material losses in the agricultural sector (Svec and Hodges, 1972; Cakmakci and Acikgoz, 1992).

Since the climate and soil factors of our country are rather variable, it is necessary to generate varieties with stable grain yield in different climate and soil conditions and whose quality characteristics are not very variable and offer them to farmers. Although the yield potential of the varieties developed in recent years is high, the yields are decreased by abiotic stress factors. Almost every year there are yield losses due to cold damage in various regions. Cold damage affects the yield negatively especially in Central Anatolia, East and Northeast Anatolia where wheat production is the most intense. The development of varieties resistant to stress factors will increase the yield and therefore the production. Wheat is affected by the cold and drought because it is planted mainly in winter in dry conditions. This is also the case in other regions. In winter and cold resistant varieties, the output after winter is 80-95%, while the output of susceptible varieties is down by 40-50%. Considering the strategic importance of wheat in the agriculture of our country, increasing the yield and production of this species will make a great contribution to the national economy. In order to increase yield, limiting factors must be eliminated. Drought, cold and high temperature are the most important factors limiting yield. Therefore, the development of varieties resistant to abiotic stress factors is very important in obtaining high yields. Resistance to stress factors is also associated with the period, duration, and severity of the factor (Kuçukozdemir, 2016). The aim of this study is to develop high yield and high quality cold resistant varieties suitable for Eastern Anatolia Region.

### Materials and Methods

This study was carried out in a randomized complete block design with three replications in the fields of East Anatolia Research Institute Erzurum Pasinler Location and Erzincan Garden Cultures Research Institute in the 2017-2018 production year. The trial was carried out between 1 September-1 October, which is the most suitable time for winter wheat cultivation. The seeds were planted with a 20 cm row spacing at a depth of 4 - 6 cm and 475 seeds per m² with a seed drill in the study (Akkaya, 1993). Parcel dimensions were arranged as 6 m x 1.2 m = 7.2 m². Half of the nitrogen fertilizer used in the trial was applied during planting and the other half during bolting while the Phosphor fertilizer was all applied with the planting at a rate of 6 kg N and 6 kg P per decare (Kiral and Ozcan, 1990; Akkaya, 1993).

13 advanced bread wheat lines, 1 candidate for registration and 6 bread wheat varieties were used in this study. The pedigrees of the varieties are given in Table 1.

### Table 1. Hybrids and pedigrees of varieties and lines in the study

| Number | Pedigree |
|--------|----------|
| 1      | DOGU 88  |
| 2      | PALANDÖKEN 97 |
| 3      | AYYILDIZ |
| 4      | ALPARSLAN |
| 5      | KARAHAN 99 |
| 6      | ALTURNA (Candidate for registration) |
| Line 1 | T67/X84W063-9-45/\KARL92/3/\GUN91/MNCH/4/\SAULESKU #44/\TR810200 |
| Line 2 | W0405D/HGF112/\W7469C/HCF012/3/\MERCAN-2 |
| Line 3 | MV DALMA//\SHARK/F4105W2.1 |
| Line 4 | T67/X84W063-9-45/\KARL92/3/\GUN91/MNCH/4/\SAULESKU #44/\TR810200 |
| Line 5 | W0405D/HGF112/\W7469C/HCF012/3/\MERCAN-2 |
| Line 6 | SAULESKU #44/\TR810200/\ORKINOS-1 |
| Line 7 | BILINMIYEN96.7 |
| Line 8 | RAN/NE701136//\C131449/\CTK/3/\CUPE/4/\TAM200/\KAUZ/5/\BWD |
| Line 9 | W96X1375-06//\OR4910006/\OR920609 |
| Line 10 | MILAN/KAUZ/6/\TOB/ERA/\TOB/CHNO7/3/\PLO/4/\VEE95/5/\KAUZ/7/\SHARK/F4105 |
| Line 11 | HXL8088//\CBRD/3/\KS91W009-6-1/\MV EMMA//\BETTY |
| Line 12 | SKAUZ//\AGRI/NAC/4/\SNI/\TRAP#1/3/\KAUZ*2/\TRAP/\KAUZ/5/\ADMIS |
| Line 13 | ARG/R16//\BEZ*2/3/\AGRI/\KS/5/\TRK13/6/\494J6.1111/\MNCH |
| Line 14 | W96X1375-06//\OR4910006/\OR920609 |

When the wheat reached harvest maturity, 50 cm was cut off from each parcel as edge effect and the remaining parts were harvested and blended with a parcel harvester (Kiral and Ozcan, 1990; Akkaya, 1993).
Observations made during the trial

Number of spikes of grain per Square meter: During the maturation period, spikes in a row in the randomly selected 1 meter area within the harvest area of each plot were counted and these values were converted to the number of spikes per square meter. **Grain yield:** The grain product collected from each parcel was harvested and blended and weighed after cleaning with a small selector. The grain yields obtained as a result of weighing were collected and converted to kg da⁻¹. **1000 grain weight:** Each piece of grain taken from the product was counted and weighed four times as 100 grains and the average was taken and multiplied with 10 to determine the 1000 grain weight g. **Hectoliter weight:** A 1 liter hectoliter measuring tool was used to weigh the grain product obtained from each parcel, weighed and calculated as kg. **Proportion of protein in grain:** Samples of wheat taken from each parcel were milled in the crushing mill and 100 g flour was obtained after which the protein rate was established in % with an NIR device. **Zeleny sedimentation:** Samples of wheat taken from each parcel were milled in the crushing mill and 100 g flour was obtained and a method developed by Elgun et al. (1987) was used to determine sedimentation as ml. **Cold tests** were carried out according to the method used by Kucukkuzdemir (2016).

Results and Discussion

In the study conducted with 20 bread wheat genotypes, significant statistical differences were found among the characteristics of the examined genotypes in Erzincan location in the studied parameters other than hectoliter weight, plant height and spike number per m². The mean values of all these properties and the statistical significance groups of the subjects according to these averages (P <0.01 and P <0.05) are given in Table 2, Table 3, Table 4 and Table 5.

### Table 2. Yield, number of spikes per m² and plant height of genotypes

| Genotypes     | Yield (kg da⁻¹) | Number of spikes per m² (units) | Plant height (cm) |
|---------------|----------------|---------------------------------|-------------------|
|               | Erzincan       | Pasinler                        | Average           | Erzincan       | Pasinler | Average |
| DOĞU 88       | 157 d-f        | 55 k                            | 106 k             | 392 ab         | 677 d-a | 535 a-e | 71     | 128 a   | 100 a   |
| PALANDÖKEN 97 | 155 d-f        | 69 j-l                          | 112 k             | 327 b          | 892 a   | 609 a-b | 68     | 125 ab  | 97 a    |
| AYYILDİS      | 231 b-e        | 39 l                            | 135 g-k           | 396 ab         | 767 a-c | 581 a-c | 73     | 118 a-c | 96 ab   |
| ALPÇALSAN     | 160 d-f        | 196 d-e                         | 178 e-h           | 415 ab         | 589 b-d | 502 a-e | 59     | 103 f   | 81 c    |
| KARAHAN 99    | 146 d-f        | 191 d-e                         | 169 e-j           | 468 ab         | 532 c-d | 500 a-e | 68     | 114 b-f | 91 a-c  |
| ALTURNA       | 203 b-e        | 113 g-k                         | 158 e-k           | 359 b          | 665 a-d | 512 a-e | 70     | 117 a-d | 94 a-c  |
| Line 1        | 159 d-f        | 138 e-h                         | 148 f-k           | 563 a          | 517 c-d | 540 a-e | 70     | 119 a-c | 95 a-c  |
| Line 2        | 105 f          | 207 cd                          | 156 e-k           | 335 b          | 484 c-d | 409 d-e | 65     | 114 b-f | 90 a-c  |
| Line 3        | 185 c-f        | 315 b                           | 250 b             | 351 b          | 604 b-d | 477 b-e | 68     | 111 c-f | 90 a-c  |
| Line 4        | 289 ab         | 124 f-j                         | 207 b-e           | 391 ab         | 753 a-c | 572 a-d | 77     | 111 c-f | 94 a-c  |
| Line 5        | 317 a          | 76 j-l                          | 197 c-f           | 476 ab         | 823 a-b | 649 a   | 71     | 111 c-f | 91 a-c  |
| Line 6        | 211 b-e        | 87 h-l                          | 149 f-k           | 408 ab         | 632 a-d | 520 a-e | 75     | 122 a-c | 98 a    |
| Line 7        | 152 d-f        | 93 g-l                          | 122 j-k           | 308 b          | 479 c-d | 393 e   | 65     | 113 b-f | 89 a-c  |
| Line 8        | 194 c-f        | 150 d-g                         | 172 e-j           | 437 ab         | 463 d   | 450 b-e | 71     | 118 a-c | 95 a-c  |
| Line 9        | 139 ef         | 175 d-f                         | 157 e-k           | 387 ab         | 488 c-d | 437 c-e | 62     | 103 f   | 83 bc   |
| Line 10       | 220 b-e        | 413 a                           | 316 a             | 341 b          | 523 c-d | 432 c-e | 78     | 108 c-f | 93 a-c  |
| Line 11       | 145 d-f        | 322 b                           | 234 b-d           | 377 b          | 493 c-d | 435 c-e | 68     | 110 c-f | 89 a-c  |
| Line 12       | 232 b-d        | 256 c                           | 244 bc            | 483 b          | 533 c-d | 441 b-e | 70     | 105 d-f | 87 a-c  |
| Line 13       | 153 d-f        | 100 g-k                         | 127 g-k           | 352 b          | 571 b-d | 461 b-e | 71     | 117 a-e | 94 a-c  |
| Line 14       | 269 c-a        | 108 g-k                         | 189 d-g           | 361 b          | 687 a-d | 524 a-e | 68     | 104 ef  | 86 a-c  |

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

When the grain yield parameter was examined according to the variance analysis table, it was observed that the location of the Pasin, the location of the Erzincan and the average of the location were important (P<0.01). Both the Number of spikes per m², hectoliter weight and plant height were found insignificant in Erzincan location (0.05<P). These two parameters were found to be important in terms of Pasinler location and average of location (P<0.01).

The yield obtained from the unit area is the most important agricultural parameter which is closely related to every branch of agriculture. According to the location averages, the highest grain yield was obtained with line 10 (316 kg da⁻¹). This line also ranked first in Pasinler location with 413 kg da⁻¹. The highest yield in the Erzincan location was found in line 5 (317 kg da⁻¹). In the study year, intensive stem rust at Pasinler location caused significant losses in yield, 1000 grain and hectoliter weights. While hectoliter values were found to be statistically insignificant in Erzincan location, those in Pasinler location and location averages were statistically very significant. In Pasinler location, the tallest plant height was found with DOĞU 88 variety (128 cm) and the shortest plant height was found in line 9 (103 cm). According to the location averages, DOĞU 88 (100 cm) and PALANDÖKEN 97 (97 cm) varieties stand out in terms of plant height (Table 2). Plant height is important in terms of hay yield especially in regions where animal husbandry is practiced and it indirectly affects grain yield (Kucukkuzdemir, 2016). Similarly to the study, Doğan (2002) conducted a two-year study in Bursa, which determined differences in plant height over the years, and reported that the average plant height ranged from 84.3 to 108.6 cm. Many
Researchers indicate that the significant differences in the plant heights of genotypes stem from genetic structures (Kaydan and Yagmur, 2008).

When the variance analysis table was analyzed, it was seen that 1000 grain weight was found to be very important in both locations and average of locations (P<0.01). In hectoliter weight, it is determined that the Erzincan location was not important (0.05<P) and Pasinler location and the average of location were very significantly (P<0.01).

The highest hectoliter weight was measured as 77.6 kg in Pasinler location and a location average of 78.2 kg was weighed in line 10 (Table 3). While the highest value in Pasinler location was measured with PALANDÖKEN 97 variety (892 units) in terms of the number of spikes per square meter, the highest value was determined in line number 5 (649) in terms of location averages (Table 2). Some yield components directly affect yield. For example, it has been determined that there is a positive and significant association between hectoliter weight and 1000 grain weight in wheat. (Dokuyucu et al., 2001). Kurt and Yagdı (2013) emphasized that in order to increase yield in wheat, it was necessary to increase the number of spikes per m², number of grains per spike as well as 1000 grain weight. Bilgin and Korkut (2005) stated that in addition to the above mentioned features, genotypes with early spike growth as well as long spike growth and maturity periods should be emphasized.

Table 3. 1000 grain weight and hectoliter

| Genotypes      | 1000 grain weight (gr) | Hectoliter (kg hl⁻¹) |
|----------------|------------------------|----------------------|
|                | Erzincan | Pasinler | Average | Erzincan | Pasinler | Average |
| DOĞU 88        | 30 g     | 16 j     | 23 h     | 77,6     | 59,2 e-g | 68,4 d-f |
| PALANDÖKEN 97  | 47 a     | 20 f-h   | 33,5 bc  | 77,2     | 59,2 e-g | 68,2 ef  |
| AYYILDIZ       | 41 b-d   | 16 j     | 28,5 fg  | 79,2     | 54,4 g   | 66,8 f   |
| ALPARSLAN      | 40 b-e   | 22 ef    | 31 de    | 77,2     | 69,6 b-d | 73,4 b-d |
| KARAHAN 99     | 42 bc    | 22 ef    | 32 c-e   | 79,2     | 66,4 cd  | 72,8 b-e |
| ALTURNA        | 41 b-d   | 20 f-h   | 30,5 ef  | 80       | 66 cd    | 73 b-e   |
| Line 1         | 36 f     | 19 gh    | 27,5 g   | 78       | 66,8 cd  | 72,4 b-e |
| Line 2         | 41 b-d   | 28 c     | 34,5 b   | 77,6     | 74 b     | 75,8 ab  |
| Line 3         | 39 c-f   | 30 b     | 34,5 b   | 77,2     | 73,6 b   | 75,4 ab  |
| Line 4         | 39 c-f   | 18 h-j   | 28,5 fg  | 80,4     | 61,2 d-f | 70,8 b-f |
| Line 5         | 39 c-f   | 18 h-j   | 28,5 fg  | 81,2     | 59,2 e-f | 70,2 c-f |
| Line 6         | 42 bc    | 19 gh    | 30,5 ef  | 78,8     | 59,2 e-g | 69 c-f   |
| Line 7         | 43 b     | 18 hj    | 30,5 ef  | 80       | 62,4 d-f | 71,2 b-f |
| Line 8         | 41 b-d   | 25 d     | 33 b-d   | 78,8     | 66,1 cd  | 72,4 b-e |
| Line 9         | 40 b-e   | 21 e-g   | 30,5 ef  | 78       | 64,1 c-e | 71,05 b-f|
| Line 10        | 41 b-d   | 32 a     | 36,5 a   | 78,8     | 77,6 a   | 78,2 a   |
| Line 11        | 37 e-f   | 30 b     | 33,5 bc  | 77,6     | 72,8 bc  | 75,2 ab  |
| Line 12        | 40 b-e   | 23 d     | 31,5 c-e | 80,4     | 67,2 b-d | 73,8 a-c |
| Line 13        | 42 bc    | 20 f-h   | 31 de    | 80       | 57,2 f-g | 68,6 d-f |
| Line 14        | 38 d-f   | 22 ef    | 30 ef    | 79,2     | 66 cd    | 72,6 b-e |
| Average        | 39,95**  | 21,95**  | 30,95**  | 78,82 ns | 65,11**  | 71,965** |

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

The amount of protein is the most commonly used criterion for determining the quality of wheat. The amount of protein may vary depending on the genetic structure and the environmental conditions in which the plant is grown. Important environmental factors affecting this are soil fertility; quantity, distribution and time of precipitation; temperature and diseases (Pomeranz, 1971; Bushuk, 1982). The protein ratio was found to be very significant in the locations and in terms of location averages (P <0.01) in this study. The highest protein ratios were measured in lines 2 (16.83%), 6 (16.80%), 8 (16.75%), and 13 (16.74%) in Erzincan location. The highest protein ratio in Pasinler location (15.74%) and the average of the locations (15.72%) was determined in line 11. The highest protein value for the location was obtained from Alturana (14.64%), which is the candidate for registration (Table 4). The higher protein ratios in Erzincan location are attributed to a more arid climate. Zeleny sedimentation value that indicates the volume of flour particles that settle after a certain time after being in a flour and lactic acid solution and then denote the characteristics of wheat flour is one of the most important indicators of the bread quality of the flour. Zeleny sedimentation tests (Peña, 2002), which are used to measure the strength or weakness of gluten structure in wheat, help breeders in early stage selection of genotypes. It is stated that higher volume bread can be made from wheat flour with a high amount of gluten and high quality, and wheat flour with these properties has a high zeleny sedimentation value (Elgun et al., 1987; Elgun et al., 2001). According to the Turkish Food Codex Wheat Flour Communiqué (Communiqué no: 2013/9) the zeleny sedimentation value for bread wheat must be at least 30 ml. The zeleny sedimentation values were statistically significant (P<0.01) in terms of location and location averages in this study. The highest zeleny sedimentation value was found in ALPARSLAN (52 ml) variety in Erzincan location, in line 1 (50 ml) in Pasinler location and in ALPARSLAN (46 ml) in terms of location average, in line 3 (45 ml) and in line 11 (45 ml).
Summer cultivation is still common, especially in regions with a short vegetation period and concerns regarding cold damage which decreases the region’s average yield. In order to increase the yield of cereals in the Eastern Anatolia Region, winter cultivation should be carried out and winter varieties suitable for this purpose should be developed. The effects of cold or winter conditions on the yield will be less as the damage to the plant will be less than to susceptible varieties due to increased resistance to cold and winter (Gusta and Fowler, 1977). We found that the cold resistance tests between genotypes were statistically significant (P<0.01) in this study. The frost tests carried out after 49 days of cold application showed that lines no. 2 and 10 had not been affected at -17 °C by showing 100% viability. Line no. 2 by showing 100% viability. Line no. 2 showed 100% viability, line no. 2 showed 100% viability, line no. 2 showed 100% viability, line no. 2 showed 100% viability.

### Table 4. Protein rate and Zeleny sedimentation value

| Genotypes       | Protein (%) | Zeleny sedimentation (ml) |
|-----------------|-------------|---------------------------|
|                 | Erzincan    | Pasinler | Average | Erzincan | Pasinler | Average |
| DOGU 88         | 14.92 b-g   | 12.19 fg | 13.56 e-g | 33 gh | 34 gh | 33.5 gh |
| PALANDÖKEN 97   | 14.11 fg    | 11.30 g | 12.71 g | 40 b-d | 23 k | 31.5 h |
| AYYILDIZ        | 14.14 d-g   | 12.56 ef | 13.35 fg | 34 fh | 36 fg | 35 fg |
| ALPARSLAN       | 15.92 ab    | 13.06 d-f | 14.49 b-e | 52 a | 40 de | 46 a |
| KARAHAN 99      | 14.31 c-g   | 14.35 bc | 14.33 b-e | 35 e-h | 37 e-h | 36 fg |
| ALTURNA         | 15.62 a-d   | 13.66 c-e | 14.64 b-d | 42 b | 39 d-f | 40.5 cd |
| Line 1          | 15.58 a-f   | 13.12 c-f | 14.35 b-e | 38 e-c | 50 a | 44 b |
| Line 2          | 16.83 a-f   | 13.34 c-f | 15.08 ab | 37 d-f | 47 a-c | 42 bc |
| Line 3          | 15.60 a-f   | 12.46 e-g | 14.03 c-f | 45 b | 45 cd | 45 a |
| Line 4          | 14.83 b-g   | 13.32 c-f | 14.075 c-f | 36 e-g | 46 bc | 41 cd |
| Line 5          | 14.71 b-g   | 13.99 b-d | 14.35 b-e | 38 e-c | 44 cd | 41 cd |
| Line 6          | 16.80 a     | 12.81 d-f | 14.81 bc | 38 e-c | 36 fg | 37 ef |
| Line 7          | 14.60 b-g   | 12.81 d-f | 13.71 d-f | 33 gh | 39 d-f | 36 fg |
| Line 8          | 16.75 a     | 13.26 c-f | 15.01 a-c | 38 e-c | 40 de | 39 de |
| Line 9          | 15.81 a-c   | 12.66 ef | 14.24 b-f | 36 e-g | 34 gh | 35 fg |
| Line 10         | 13.92 g     | 12.75 d-f | 13.34 fg | 40 b-d | 42 d | 41 cd |
| Line 11         | 15.69 a-c   | 15.74 a | 15.72 a | 41 bc | 49 ab | 45 a |
| Line 12         | 14.43 b-g   | 14.88 ab | 14.66 b-d | 34 fh | 44 cd | 39 de |
| Line 13         | 16.74 a     | 12.26 fg | 14.50 b-e | 40 b-d | 27 j | 33.5 gh |
| Line 14         | 14.99 b-g   | 12.65 ef | 13.82 d-f | 32 h | 32 h | 32 h |
| **Average**     | 15.32**     | 13.16** | 14.24** | 38.1** | 39.2** | 38.65** |

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

### Table 5. Cold test viability rates

| Genotypes       | -17°C (%) | -19°C (%) | -21°C (%) |
|-----------------|-----------|-----------|-----------|
| DOGU 88         | 93 a-c    | 93 ab     | 67 a      |
| PALANDOKEN      | 90 a-c    | 87 a-c    | 37 c-e    |
| AYYILDIZ        | 93 a-c    | 87 a-c    | 43 b-e    |
| ALPARSLAN       | 93 a-c    | 93 ab     | 60 ab     |
| KARAHAN 99      | 93 a-c    | 93 ab     | 43 b-e    |
| ALTURNA (candidate) | 97 ab | 93 ab     | 60 ab     |
| Line 1          | 90 a-c    | 77 b-d    | 53 a-c    |
| Line 2          | 100 a     | 97 a      | 47 a-e    |
| Line 3          | 90 a-c    | 80 a-c    | 67 a      |
| Line 4          | 93 a-c    | 87 a-c    | 47 a-e    |
| Line 5          | 87 a-c    | 83 a-c    | 47 a-e    |
| Line 6          | 87 a-c    | 87 a-c    | 37 c-e    |
| Line 7          | 93 a-c    | 90 ab     | 43 b-e    |
| Line 8          | 80 bc     | 77 b-d    | 57 a-c    |
| Line 9          | 90 a-c    | 83 a-c    | 43 b-e    |
| Line 10         | 100 a     | 80 a-c    | 57 a-c    |
| Line 11         | 90 a-c    | 77 b-d    | 50 a-d    |
| Line 12         | 83 a-c    | 60 de     | 40 b-e    |
| Line 13         | 77 c      | 70 cd     | 30 de     |
| Line 14         | 90 a-c    | 53 e      | 27 e      |
| **Average**     | 91**      | 82**      | 48**      |

According to the Duncan test, the averages shown with the same letter are not important in their group (p<0.05)
four different cold weather applications (0, 21, 35 and 49 days) and the highest durability was determined 49 days after the cold application. Cold and winter hardness emerges as a very important feature for high yield in the varieties developed in our region. Therefore, Doğu 88 and Alparslan varieties, the candidate variety Alturna, lines number 1, 3, 8, 10 and 11 were found to be resistant to -21 °C according to LT50. Pomery and Fowler (1973) stated that durability tests carried out under controlled conditions can be applied at all times and results are achieved in a short time. Küçüközdemir et al. (2013) carried out a controlled study which compared the methods of cold resistance and determined that a bread wheat referred to as Krasunia O’deska and a durum wheat named Betadur had the highest durability. Yildirim (2003) carried out a trial under controlled conditions with 15 wheat and 9 barley genotypes and determined that Norstar wheat (-10.9 °C) and Dictoo barley (-3.5 °C) varieties were the most durable genotypes. In a study involving cold tests carried out under controlled conditions with 90 local genotypes and 6 varieties of registered bread wheat, the registered varieties displayed a higher durability compared to local genotypes and the most durable genotype was Alparslan variety (Kuçukozdemir and Tosun, 2014). In the study conducted by Küçüközdemir et al. (2020), results similar to our study were found.

Conclusion

In this study carried out in Pasinler and Erzincan locations, the yield, spike number per square meter, hectoliter weight, protein ratio, zeleny sedimentation rate and cold resistance in 3 different degrees (-17, -19 and -21 °C) of genotypes were compared with the varieties in the study. Temperature stress reduced yield in Erzincan while stem rust reduced yield as well as 1000 grain and hectoliter weight in Pasinler. Line 10, which has high values in terms of yield and other characteristics at both locations is considered suitable for regional conditions and may have a profitable production potential for producers. Lines 1, 2, 3, 4, 5, 8 and 10 stand out in terms of cold resistance. The high durability of these lines is due to the fact that they are well adapted to the conditions of the region and have been transferred to advanced breeding stages at the end of a long-term breeding process.

Recent climate changes have generated new biotic and abiotic stresses. One of them is stem rust which coincides with the grain filling period of the plants. It has been concluded that resilience to this disease, which has not been considered important in our region to date, should be included in the breeding targets and that resistant varieties should be developed.

Furthermore, including cold durability studies into the breeding programs of regions such as Eastern Anatolia Region with harsh winters and high frost risk will play an important role in preventing the producers in the region from the impact of winter damage and minimize yield loss.

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