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# STUDY OF DROUGHT TOLERANCE OF WINTER OAT VARIETIES

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## Abstract

This research was conducted during the period 2019-2021 at the Institute of Agriculture in Karnobat, Bulgaria. In order to establish suitable parents for a selection of drought resistant varieties, twelve accessions of introduced winter oats were studied. The genetic similarity and distance of the accessions was determined by means of cluster analysis.

The highest drought resistance was exhibited by varieties Lustre, Image, Westfinnischer Schwarz, Powys, Lee and Fulghum . A good combination of drought resistance, grain weight per spike and 1000-grain weight was found for Lustre, Image and the Heros variety was from the accessions group with medium drought resistance. The cluster analysis revealed that the promising combinations can be obtained by crossing varieties from the most remote clusters, such as Lustre (first cluster) with varieties Panema, Roanoke, and Winter Turf from the third cluster.

**Keywords:** winter oats, accessions, drought resistance, productivity, cluster analysis

## INTRODUCTION

The successful oat cultivation under the conditions of unstable and unpredictable climate increasingly highlights the issue of adaptation and ecological plasticity of oat varieties (Valchev & Savova, 1995, Kuzmova, 2001, Yakushev, 2016). One of the major traits significantly affecting oat productivity is its level of drought resistance (Valchev & Savova, 2000, Teklić et al., 2021; Ma et al., 2021). Drought is a phenomenon that is all too common in Bulgaria and has a particularly strong impact on a crop known for its need of moisture (Batalova et al., 2008).

The Karnobat region is characterized by frequent and extended periods without precipitation. Every third year is unfavourable for oat development in terms of soil moisture (Valchev, 1994). Therefore, when creating high-yielding varieties, it is necessary to work towards increasing the tolerance of genotypes to environmental stress (Yau & Hamblin, 1994; Valchev & Savova, 1995; Kuzmova, 2001; Canales et al., 2019).

Oats have been found to have a longer critical period of soil moisture deficit than wheat and barley (Skazkin, 1961; Savova, 2001). It was proven that its greatest soil moisture requirement occurs during the stem elongation - heading period, which coincides with the formation of its generative organs (Larson, 1988, Valchev & Savova, 2000, Savova, 2001, Raguindin et al., 2020).

The most effective way to overcome the harmful impact of drought and the related reduction in yield and grain quality is to develop a starting material and varieties with increased drought resistance (Batalova et al., 2014, Valchev & Savova, 2000, Lyzlov, 1988; Sánchez-Martín et al., 2015; Savova et al., 2015). Grouping of accessions based on specific traits or a complex of traits can greatly facilitate their use in breeding programs (Gocheva, 2020).

The aim of this study was to determine the level of drought resistance in winter oat accessions and to identify suitable sources for the selection of varieties which combined high drought resistance and productivity.

## MATERIALS AND METHODS

The study was conducted during the period 2019-2021 in the experimental field of the Institute of Agriculture, Karnobat. Twelve accessions of introduced winter oats were examined. Each accession was sown on a 2 $m^2$ plot according to a standard scheme in three replications. During the period of stem elongation - heading, a set of physiological indicators such as leaf water content (%), residual water deficit (%), water holding capacity (%), electrolyte exosmosis were assessed. ().

The leaf water content was estimated (in %) by drying ten leaves at 105°C to the fresh mass. Residual water deficit - when determining this indicator early in the morning (6-7), ten fully developed leaves were taken and were immediately weighed on an analytical balance (W1). The leaves were then placed in a desiccator with water at room temperature for water saturation. After 24 hours, the leaves were dried with filter paper and weighed again (W2). The same sheets for dried to constant weight in a dryer at t° 95-100 °C and reweighed ($W_0$).

The water holding capacity of plant leaves was characterized as the relative amount of water lost in the leaves, expressed in percentages (3 repetitions).

Electrolyte exosmosis - when determining this indicator, oat leaves were divided lengthwise into two equal halves, removing the central vein. One half was placed for two hours in distilled water and the other half for 5 hours at a temperature of 25°C, after which the wilted leaves were also placed for 2 hours in distilled water. The resistance of the distilled water was read with a conductometer OK 102/l after removing the leaves. , The degree of dry resistance was assessed not by the absolute value of electrolyte exosmosis, but by the degree of its increase compared to the control, which was assumed to be constant. Based on these indicators, a drought resistance coefficient was determined for each accession according to Valchev (1994). with.

A biometric analysis was conducted on 30 plants from each accession (10 plants from each replication) to determine some productivity parameters – panicle length (cm), number of spikelets and grains per panicle, grain weight per panicle (g), and 1000-grain weight (g).

Microsoft Excel and JMP version 5.0.1a (2002) were used for data processing. To group the genotypes based on genetic similarity and genetic distance for the studied varieties, a hierarchical cluster analysis was applied (Ward, 1963).

## RESULTS AND DISCUSSION

Table 1 presents the physiological indicators (leaf water content (%), residual water deficit (%), water holding capacity (%), electrolyte exosmosis) of winter oat accessions - with high, medium and low drought resistance in the period 2019-2021.

A high leaf water content was reported in samples Lustre (75.96%), Image (74.87%), Westfinnischer Schwarz (74.01%), Powys (76.36%), Lee (72.05%) and Fulghum (69.30%). A high water holding capacity was reported for varieties - Panema (66%) Yeats (64%) and Roanoke (64%). Ahight residual water deficit was estimated for varieties Winter Turf (13.59%), Panema (11.58%) and Roanoke (11.34%). A hight electrolyte exosmosis was found for varieties Carbeen (7.35%) и Yeats (7.33%).

Figure 1 shows the coefficient of drought resistance of twelve winter oat samples. Most of the varieties have good drought tolerance, with high coefficients estimated forvarieties Lustre, Image, Westfinnischer

Schwarz, Powys, Fulghum and Lee. The varieties that showed medium drought resistance were Carbeen, Heros, Yeats. They could be used in the oat breeding program as sources towards improved drought tolerance (Figure 1).

**Table 1.** The average values of physiological indicators of winter oat accessions for the period 2019-2021

| Accessions | The leaf water content, % | Water holding capacity, % | Residual water deficit, % | Electrolyte exosmosis |
|---|---|---|---|---|
| Lustre | 75.96 | 60 | 2.51 | 5.07 |
| Image | 74.87 | 60 | 5.55 | 4.20 |
| Westfinnischer Schwarz | 74.01 | 60 | 4.91 | 5.39 |
| Powys | 76.36 | 58 | 4.81 | 6.52 |
| Lee | 72.05 | 60 | 5.02 | 6.51 |
| Fulghum | 69.30 | 58 | 7.37 | 5.05 |
| Carbeen | 75.48 | 62 | 7.68 | 7.35 |
| Heros | 74.19 | 62 | 8.38 | 6.94 |
| Yeats | 70.90 | 64 | 8.43 | 7.33 |
| Panema | 74.04 | 66 | 11.58 | 6.44 |
| Roanoke | 69.76 | 64 | 11.34 | 6.63 |
| Winter Turf | 71.65 | 58 | 13.59 | 5.46 |

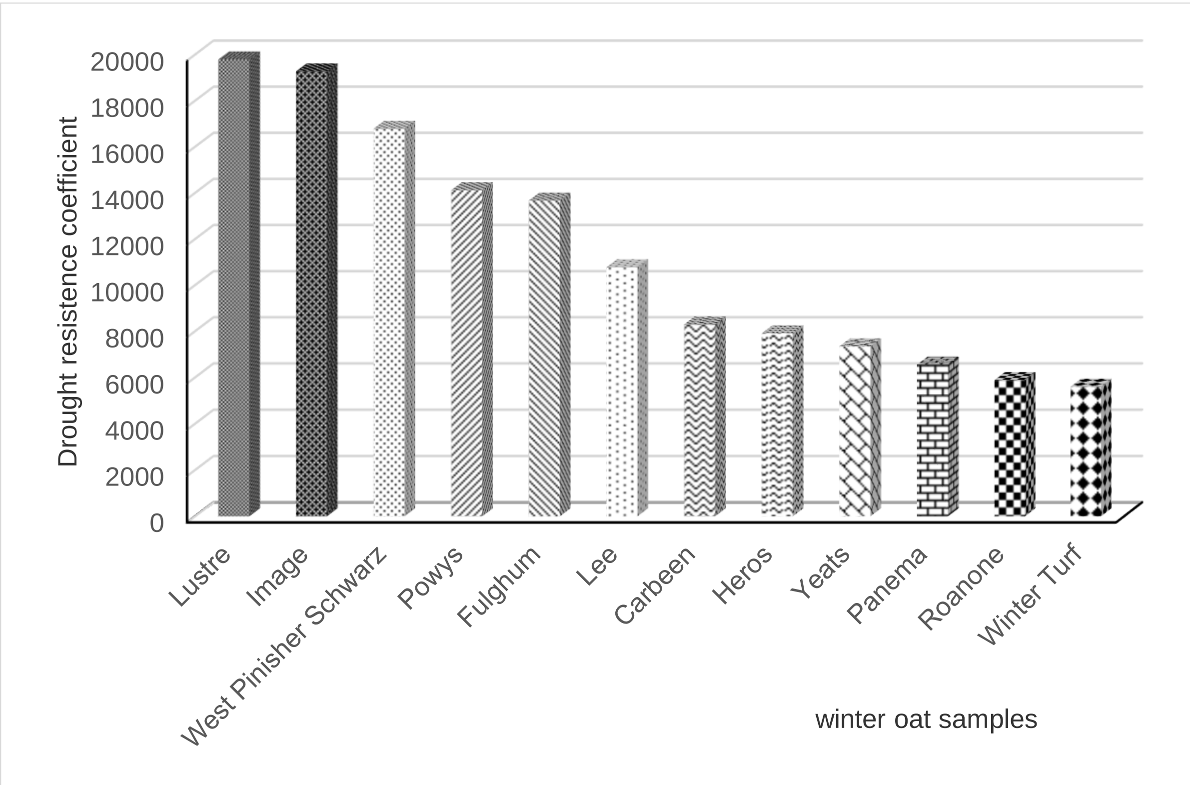


**Figure 1.** Coefficient of drought resistance of winter oat varieties

Table 2 presents the average values and variation of some indicators related to yield in oat samples for the three year`s period of the study. The length of the panicle in the samples varies from 16.15 to 26.56 cm and has the lowest coefficient of variation of 13.73 %. The observed samples have a strong dispersion of the values of the indicators – the number of ears in one panicle, the number of grains in one panicle and weight of the grain in the panicle. The number of spikelets in the panicle in the samples varied from 17.30 to 77.10, with a coefficient of variation of 42.98 %. The number of grains in one panicle varied from 32.35 to 109.25 at CV 38.50 %. The weight of the panicle grain in the samples varied from 0.95 g to 4.05 g and CV 49.75 %. The mass per 1000 grains in the samples ranged from 23.50 g to 35.56 g with CV 13.95 %. According to the study, the Luster variety has the highest values for all studied indicators.

**Table 2.** The average values and variation of some indicators related to yield in oat varieties for the period 2019-2021

| **Accessions** | **Panicle length, cm** | **Number of spikelets per panicle** | **Grain number per panicle** | **Panicle weight, g** | **1000-grain weight, g** |
|---|---|---|---|---|---|
| 1 Lustre | 26.56a | 77.10a | 109.25a | 4.05a | 35.56a |
| 2 Image | 19.69def | 49.65bc | 70.30bc | 2.29b | 33.00abc |
| 3 Westfinnischer Schwarz | 20.79cde | 41.45bcd | 51.00bcd | 1.50bcd | 31.70abcd |
| 4 Powys | 22.97bcd | 37.50cde | 50.87bcd | 1.52bcd | 31.00abcde |
| 5 Lee | 20.96bcde | 26.70efg | 44.95bcd | 1.29bcd | 28.00bcdef |
| 6 Fulghum | 20.92bcde | 30.35def | 42.15cd | 1.12cd | 27.75cdef |
| 7 Carbeen | 16.15g | 19.55fg | 34.35d | 0.95d | 27.25cdef |
| 8 Heros | 17.39fg | 17.30g | 32.35d | 1.18cd | 35.00ab |
| 9 Yeats | 19.51ef | 37.95cde | 68.45bc | 2.13bc | 31.75abcd |
| 10 Panema | 24.14ab | 52.10b | 72.80b | 1.86bcd | 24.00ef |
| 11 Roanoke | 20.87bcde | 41.10bcd | 61.10bcd | 1.53bcd | 25.25def |
| 12 Winter Turf | 23.77abc | 27.10efg | 39.00d | 1.06d | 23.50f |
| Avarage | 21.14 | 38.15 | 56.38 | 1.71 | 29.48 |
| S | 2.90 | 16.40 | 21.71 | 0.85 | 4.11 |
| CV, % | 13.73 | 42.98 | 38.50 | 49.75 | 13.95 |
| LSD | 3.32 | 12.69 | 29.24 | 1.02 | 7.07 |

To obtain the accurate information on suitable combinations between the studied traits and to enhance the efficiency of the breeding process, a hierarchical cluster analysis was conducted (Figure 2).

Based on the indicators of panicle length, spikelets per panicle, grains per panicle, grain weight per panicle, 1000-grain weight, and drought resistance coefficient, the accessions were grouped into clusters. According to the dendrogram, the accessions were divided into three clusters. The first cluster included the Lustre variety, as it had the highest drought resistance, the longest panicle length, the most spikelets per panicle, the largest grain per panicle, and the highest grain weight per panicle and 1000-grain weight among all the other varieties. The second cluster was comprised of eight varieties. The most closely related in this group were Westfinnischer Schwarz and Powys, Lee and Fulghum, which formed subgroups with the least distant units. The similarity between Westfinnischer Schwarz and Powys was in the grain number per panicle and 1000-grain weight, while between Lee and Fulghum, it was panicle length, grain weight per panicle, and 1000-grain weight. The third cluster included three of the accessions – Panema, Roanoke, Winter Turf, characterized by relatively low 1000-grain weight and low drought resistance.

It is possible to obtain effective combinations by crossing varieties from the most distant clusters, i.e., the Lustre variety (first cluster) with varieties Panema, Roanoke, Winter Turf, which formed the third cluster.

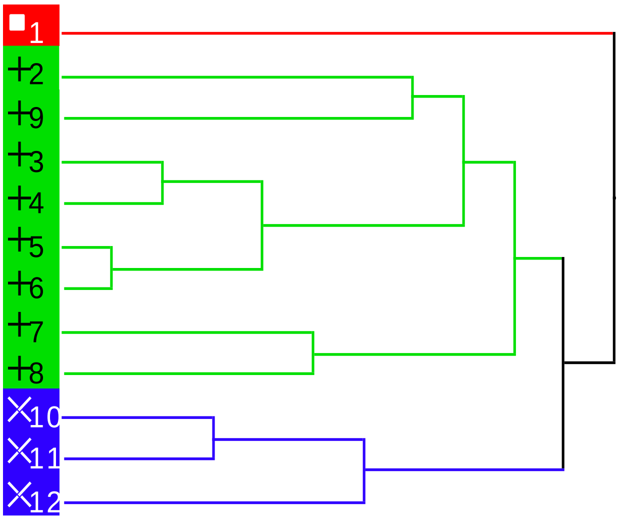


**Figure 2.** Dendrogram of drought resistance coefficient and yield structural elements in winter oat accessions

***Legend:*** 1- Lustre; 2- Image; 3- Westfinnischer Schwarz; 4- Powys; 5- Lee; 6- Fulghum; 7- Carbeen; 8-Heros; 9- Yeats; 10- Panema; 11- Roanoke; 12- Winter Turf.

## CONCLUSION

The highest drought resistance exhibited varieties Lustre, Image, Westfinnischer Schwarz, Powys, Lee, and Fulghum. Additionally, the Lustre and Image varieties showed a good combination of drought resistance, grain weight per panicle, and 1000-grain weight. The same characteristics were observed for Heros variety which was part of the group of accessions with moderate drought resistance. Among the studied varieties were identified three cluster groups. It is expected that effective combinations could be achieved by crossing varieties from the most distant clusters, i.e., the Lustre variety (first cluster), with varieties from the third cluster - Panema, Roanoke, Winter Turf.

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