# VARIATION OF DROUGHT STRESS INDEX AT WINTER WHEAT CULTIVARS IN CENTRAL PART OF OLTENIA

# VARIABILITATEA INDICELUI DE SUSCEPTIBILITATE LA SECETĂ, LA SOIURI DE GRÂU DE TOAMNĂ, ÎN CONDIȚIILE ZONEI CENTRALE A OLTENIEI

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***Abstract:*** *Seventy-six wheat cultivars were compared in the field of ADRS Simnic during three years 2005-2007, where 2005 was a year with rainfall conditions and 2007 year with drought conditions. We identified cultivars of various origins with good results concerning the yield in the drought conditions on the base of drought stress index: TOL = stress tolerance; MP = mean productivity; GMP = geometric mean; SSI = stress susceptibity index; STI = stress tolerance index. The wheat cultivars with good results in stress and non-stress conditions were: Romanian cultivars: Alex, Glosa, Romulus, Boema, Delabrad, Crina, Şimnic 30, Rapid and Dor; Hungarian cultivar Martina; German cultivars Exotic and Cubus; French cultivar Aztec; cultivars Orion and Frini. These genotypes may serve as sources of germoplasm for breeding for drought tolerance.*

***Rezumat:*** *Şaptezeci şi şase de soiuri de grâu de toamnă au fost testate în câmpul experimental de la SCDA Şimnic, timp de trei ani (2005-2007), 2005 fiind un an normal pentru cultura grâului şi 2007 an extreme de secetos. Au fost identificate soiuri de diferite proveniențe cu bune rezultate privind producția în condiții de secetă, pe baza următorilor indici: TOL = toleranță la secetă; MP = producție medie; GMP = medie geometrică; SSI = indicele de susceptibilitate la secetă; STI = indicele de toleranță la stres. Soiurile care au obținut rezultate bune au fost: soiurile românești: Alex, Glosa, Romulus, Boema, Delabrad, Crina, Şimnic 30, Rapid şi Dor; soiul unguresc Martina; soiurile germane: Exotic şi Cubus; soiul franțuzesc Aztec; soiurile Orion şi Frini. Aceste genotipuri pot servi ca surse de germoplasmă pentru ameliorarea toleranței la secetă.*

***Key words:*** *wheat, drought stress, stress susceptibility index, stress tolerance index*
***Cuvinte cheie:*** *grâu, rezistența la secetă, indice desusceptibilitate la stress, indice de tolerență la stres*

## INTRODUCTION

The ability of wheat cultivars to perform reasonably well in variable rainfall and water stressed environments is an important trait for stability of production under drought stress conditions (PIRAYVATLOU, 2001). Drought resistance is defined as the relative yield of a genotype compared to other genotypes subjected to the same drought stress.

For identifying genotypes with high yield potential and high stress tolerance, we used several drought stress index or selection criteria: TOL = stress tolerance (ROSIELLE and HAMBLIN, 1981); MP = mean productivity; GMP = geometric mean (RAMIREZ and KELLY, 1998); SSI = stress susceptibity index (FISHER and MAURER, 1978); STI = stress tolerance index (FERNANDEZ, 1992).

Among the stress tolerance indicators, a larger value of TOL and SSI represent relatively more sensitivity to stress, thus a smaller value of TOL and SSI are favoured. Selection based on these two indices favours genotypes with low yield under non-stress conditions and high yield under stress conditions (GOLABADI et al., 2006). Selection based on STI and GMP will result in genotypes with higher stress tolerance and yield potential will be selected (FERNANDEZ, 1992).

## MATERIAL AND METHODS

Seventy-six wheat cultivars of different origin were studied in field experiments during three years (2005-2007) at Simnic Agricultural Research Station where 2005 was a rainfall year with normal conditions and 2007 – drought conditions year. For each cultivar we calculated:

**TOL** - the differences in yield between the stress (Ys) and non-stress conditions (Yp).

**MP** as the average yield of Ys and Yp.

**GMP** with formula $\sqrt{Ys.Yp}$

SSI – stress susceptibility index expressed by following relationships

**SSI** = [1-Ys/Yp]/SI where SI ) stress intensity and is estimated as $\left[1-\left(\frac{\overline{Ys}}{\overline{Yp}}\right)\right]$ where $\overline{Ys}$ = mean yield over all genotypes evaluated under stress conditions; $\overline{Yp}$ = mean yield over all genotypes evaluated under non-stress conditions

**STI =** stress tolerance index $\left[Yp.Ys / \overline{Yp^2}\right]$

The results were grouped from different provenience of wheat cultivars.

## RESULTS AND DISCUSSION

The Romanian cultivars, most from tested material-recorded under normal conditions, yield values among 4050 kg/ha (Albota cultivar) and 6960 kg/ha (Alex cultivar) their average being by 5594 kg/ha.

Under drought conditions yield values oscillated among 2230 kg/ha (Beti) and 3500 kg/ha (Alex), with an average by 2855 kg/ha. By stress tolerance point of view (TOL) were pointed out: Albota, Flamura85, Gabriela and Fundulea4 cultivars with the lowest values. But this indicator is not enough for the stress tolerance of these genotypes. Using GMP pointed out the following cultivars: Alex (4935), Glosa (4765 kg/ha) and Romulus (4605 kg/ha) (table 1).

On average, Romanian cultivars recorded a GMP value by 3996 kg/ha. Simultaneously use of SSI values and higher Yp values pointed out Romulus, Glosa, Crina and Alex cultivars.

The average value for SSI at Romanian cultivars was lower than 1 (0.879) indicating drought stress tolerance. After STI value Alex, Glosa and Romulus there are in the first group followed by Boema, Delabrad, Crina, Gruia, Simnic30, Rapid and Dor with STI higher than 0.600.

Generally, Romanian cultivars recorded STI=0.560, the highest value in this experiment so that they are the most tolerant at drought conditions.

Tested Hungarian cultivars registered under normal conditions yield values among 4042 kg/ha (GK Othalom) and 5880 kg/ha (Mariska) and their average was with 14% lower than Romanian cultivars average. Under stress conditions the limits for production were 1590 kg/ha (GK Elet) and 3380 kg/ha (Martina), their average being also with 14% lower than Romanian cultivars average. After GMP calculations were evidently Martina, Serina and Mariska cultivars and this order is the same using STI value also (table 2).

Regarding the Austrian and German cultivars, their production under normal conditions is practically equal with the Romanian; while under stress conditions, it is 7% lower than the Romanian yield. Using Yp values, Exotic (7470 kg/ha) and Cubus (7040 kg/ha) cultivars have higher yields comparatively with autochthon cultivars. Under stress conditions the highest Ys value is recorded by Carolina cultivar. MP and GMP averages are also

practically equal with those of Romanian cultivars. GMP and STI values point out that Exotic and Cubus cultivars have drought tolerance. In average, STI value for Austrian and German cultivars is close to the Romanian value and with 0.107 over the Hungarians (table 3).

*Table 1.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from Rumanian wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotype | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| BOEMA | 5500 | 3420 | 2080 | 4460 | 4337 | 0.71 | 0.658 |
| ROMULUS | 6690 | 3170 | 3520 | 4930 | 4605 | 0.99 | 0.743 |
| DELABRAD | 5730 | 3000 | 2730 | 4365 | 4146 | 0.90 | 0.602 |
| GLOSA | 6820 | 3330 | 3190 | 5075 | 4765 | 0.98 | 0.795 |
| FL 85 | 4700 | 2930 | 1710 | 3815 | 3711 | 0.71 | 0.482 |
| CRINA | 6130 | 3140 | 2990 | 4635 | 4387 | 0.92 | 0.674 |
| IZVOR | 4490 | 2860 | 1630 | 3675 | 3583 | 0.72 | 0.450 |
| DROPIA | 5440 | 2740 | 2700 | 4090 | 3861 | 0.94 | 0.522 |
| GRUIA | 5670 | 3100 | 2570 | 4385 | 4192 | 0.86 | 0.615 |
| Ş 30 | 6560 | 2650 | 3910 | 4605 | 4169 | 1.12 | 0.609 |
| ALEX | 6960 | 3500 | 3460 | 5230 | 4935 | 0.94 | 0.853 |
| F4 | 4420 | 2610 | 1810 | 3515 | 3396 | 0.77 | 0.404 |
| RAPID | 6420 | 2940 | 3480 | 4680 | 4345 | 1.02 | 0.661 |
| FAUR | 6000 | 2510 | 3490 | 4255 | 4070 | 1.10 | 0.527 |
| Lv 34 | 5550 | 2490 | 3060 | 4020 | 3717 | 1.04 | 0.484 |
| DOR | 6820 | 2650 | 4170 | 4735 | 4251 | 1.15 | 0.633 |
| BRIANA | 5310 | 2510 | 2800 | 3910 | 3651 | 0.99 | 0.467 |
| ALBOTA | 4050 | 3300 | 750 | 3675 | 3656 | 0.35 | 0.468 |
| BETI | 4140 | 2230 | 1910 | 3185 | 3038 | 0.87 | 0.323 |
| GABRIELA | 4560 | 2830 | 1730 | 3695 | 3592 | 0.72 | 0.452 |
| GASPAROM | 4600 | 2430 | 2170 | 3515 | 3378 | 0.89 | 0.391 |
| TRIVALE | 6510 | 2480 | 4030 | 4495 | 4018 | 1.17 | 0.565 |
| **Mean** | **5594** | **2855** | **2739** | **4225** | **3996** | **0.897** | **0.560** |

*Table 2.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from Hungarian wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotype | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| MARTINA | 5730 | 3380 | 2350 | 4555 | 4401 | 0.77 | 0.678 |
| SERINA | 5710 | 2850 | 2860 | 4280 | 4034 | 0.95 | 0.570 |
| MARISKA | 5880 | 2750 | 3130 | 4315 | 4021 | 1.00 | 0.566 |
| GK PINKA | 4190 | 2620 | 1570 | 3405 | 3313 | 0.71 | 0.384 |
| Mv EMESE | 4170 | 2240 | 1930 | 3205 | 3056 | 0.87 | 0.327 |
| Mv MAMBO | 4130 | 2190 | 1940 | 3160 | 3007 | 0.89 | 0.317 |
| MADRIGAL | 4940 | 2570 | 2370 | 3755 | 3563 | 0.91 | 0.445 |
| GK ELET | 4960 | 1590 | 3370 | 3275 | 2808 | 1.28 | 0.276 |
| GK MISKA | 5071 | 2290 | 2781 | 3681 | 3407 | 1.03 | 0.407 |
| GK PETUR | 4243 | 1870 | 2373 | 3057 | 2817 | 1.06 | 0.278 |
| GK OTHALOM | 4042 | 2756 | 1286 | 3398 | 3338 | 0.60 | 0.390 |
| **Mean** | **4824** | **2464** | **2360** | **3644** | **3433** | **0.915** | **0.422** |

*Table 3.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from Austrian German wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotype | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| CAROLINA | 5322 | 3130 | 2192 | 4226 | 4081 | 0.77 | 0.583 |
| EXOTIC | 7470 | 2840 | 4630 | 5155 | 4606 | 1.17 | 0.743 |
| DUNAI | 5220 | 2780 | 2440 | 4000 | 3809 | 0.90 | 0.508 |
| MEUNIER | 6050 | 2660 | 3390 | 4355 | 4012 | 1.06 | 0.564 |
| JOSEF | 4580 | 2660 | 1920 | 3620 | 3490 | 0.79 | 0.427 |
| CORDIALE | 5970 | 2540 | 3430 | 4255 | 3894 | 1.08 | 0.531 |
| CUBUS | 7040 | 2520 | 4520 | 4780 | 4212 | 1.21 | 0.621 |
| FRIDOLINE | 4920 | 2420 | 2500 | 3670 | 3450 | 0.96 | 0.417 |
| CAPO | 4523 | 2340 | 2183 | 3432 | 3253 | 0.91 | 0.371 |
| **Mean** | **5677** | **2654** | **3013** | **4166** | **3867** | **0.98** | **0.529** |

Even if average yield value under normal conditions at ex-Russian cultivars is very closely to Romanians, these are inferior to Ys average that is with 30% below autochthon cultivars. None of these cultivars had higher than 4000 kg/ha or 0.600 GMP respectively STI values. Also SSI values for all these, except one, were higher than 1.00 suggesting that are not proper for this area (table 4).

*Table 4.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from Russian Ukrainian wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotype | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| BEZOSTAIA | 5040 | 2680 | 2360 | 3860 | 3675 | 0.88 | 0.473 |
| KJAJNA | 5430 | 1520 | 3910 | 3475 | 2873 | 1.36 | 0.289 |
| KHVYLIA | 5430 | 2340 | 3090 | 3885 | 3565 | 1.07 | 0.445 |
| KOSKA | 6100 | 2480 | 3620 | 4290 | 3889 | 1.11 | 0.530 |
| DEMETRA | 6450 | 1250 | 5200 | 3850 | 2839 | 1.52 | 0.282 |
| MIRONOVSK | 6470 | 1880 | 4590 | 4175 | 3488 | 1.34 | 0.426 |
| OFELIA | 4110 | 1780 | 2330 | 2945 | 2705 | 1.07 | 0.256 |
| KRASNODAR | 6110 | 1970 | 4140 | 4040 | 3469 | 1.29 | 0.422 |
| LADA | 4950 | 1860 | 3090 | 3405 | 3034 | 1.17 | 0.322 |
| PRELOMA | 5190 | 2340 | 2850 | 3765 | 3485 | 1.04 | 0.425 |
| VESTA | 6820 | 1810 | 5010 | 4315 | 3513 | 1.39 | 0.432 |
| **Mean** | **5645** | **1992** | **3653** | **3819** | **3353** | **1.20** | **0.391** |

Comparatively with the autochthone, the French material is placed immediately after the German material. French cultivars have also Yp and Ys averages practically equal with Romanians. Keeping into account GMP and STI values from this material evidently is Aztec cultivar. Generally, French cultivars as a consequence of SSI and STI values are close to Romanian cultivars, being appropriate for planting in areas with drought incidence excepting Renan and Enesco (table 5).

*Table 5.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from French wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotyp | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| AZTEC | 5930 | 3370 | 2570 | 4650 | 4470 | 0.81 | 0.700 |
| CEZANNE | 5430 | 3010 | 2420 | 4220 | 4043 | 0.84 | 0.572 |
| BERCY | 5530 | 2870 | 2660 | 4200 | 3984 | 0.91 | 0.556 |
| ENESCO | 4650 | 2830 | 1820 | 3740 | 3628 | 0.74 | 0.461 |
| APACHE | 5630 | 2670 | 2960 | 4150 | 3877 | 0.99 | 0.526 |
| RENAN | 4320 | 2170 | 2150 | 3245 | 3062 | 0.94 | 0.328 |
| **Mean** | **5248** | **2820** | **2428** | **4034** | **3847** | **0.872** | **0.524** |

Cultivars that entered from Israel after the results obtained for all indicator categories are not suitable for planting under drought conditions. Recorded values were below of Romanians thus: 16% less for Yp, 30% less Ys value, 28% less for GMP and 0.263 less for SSI (table 6).

Two cultivars inside of the group of cultivars with different origin showed very good indicators: Orion (GMP=4801 kg/ha, SSI=0.780, STI=0.807) and Frini (GMP=4151 kg/ha, SSI=0.750, STI=0.603). Presented cultivars belonging to different categories were identified like having yield potential and high drought tolerance (table 7).

*Table 6.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from Israeli an cultivar evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotyp | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| HAZERA 307 | 3700 | 1790 | 1910 | 2745 | 2574 | 0.97 | 0.232 |
| BHASH | 3890 | 1800 | 2090 | 2845 | 2646 | 1.01 | 0.245 |
| SHOHAM | 5440 | 2520 | 2920 | 3980 | 3703 | 1.01 | 0.480 |
| DARIEL | 3460 | 1910 | 1550 | 4675 | 2571 | 0.85 | 0.231 |
| **Mean** | **4123** | **2005** | **2118** | **3064** | **2875** | **0.96** | **0.297** |

## CONCLUSIONS

Romanian cultivars are the best adapted for the central part of Oltenia and immediately under these are placed Austrian, German and French cultivars in their totality. Cultivars with yield potential also under normal and stress conditions are the Romanians: Alex, Glosa, Romulus, Boema, Delabrad, Crina, Simnic30, Rapid and Dor; Hungarians: Martina; German cultivars Exotic and Cubus; French cultivar: Aztec; Orion and Frini cultivars. Comparatively with SSI (drought sensitivity index) is obviously that STI (stress tolerance index) is a more effectively indicator for drought tolerance characterization. In both conditions STI indicates the cultivars with high yields.

*Table 7.*

Estimation of stress tolerance attributes from the potential yield and the stress yield data from different provenience wheat cultivars evaluated for intensity stress = 0.53 at ARDS Simnic 2005-2007

| Genotype | Yp | Ys | TOL | MP | GMP | SSI | STI |
|---|---|---|---|---|---|---|---|
| ORION | 6280 | 3670 | 2610 | 4975 | 4801 | 0.78 | 0.807 |
| FRINI | 5350 | 3220 | 2130 | 4285 | 4151 | 0.75 | 0.603 |
| KRISTINA | 4690 | 1500 | 3190 | 3095 | 2652 | 1.28 | 0.246 |
| DEFENCE | 5260 | 2680 | 2580 | 3970 | 3755 | 0.93 | 0.494 |
| SOLOMON | 5230 | 1660 | 3570 | 3445 | 2946 | 1.29 | 0.304 |
| ALBATROS | 6370 | 1900 | 4470 | 4135 | 3479 | 1.32 | 0.424 |
| ROWHIDE | 5010 | 2010 | 3000 | 3510 | 3173 | 1.13 | 0.353 |
| VORONA | 5210 | 1940 | 3270 | 3575 | 3179 | 1.18 | 0.354 |
| GEORGIA 1 | 4150 | 2010 | 2140 | 3080 | 2888 | 0.97 | 0.292 |
| HOFF | 4990 | 2040 | 2950 | 3515 | 3191 | 1.11 | 0.357 |
| COLUMNA | 4400 | 1710 | 2690 | 3055 | 2773 | 1.15 | 0.264 |
| PATTON | 6910 | 1200 | 5710 | 4055 | 2880 | 1.56 | 0.290 |
| **Mean** | **5321** | **2128** | **3193** | **3725** | **3365** | **1.12** | **0.398** |

**LITERATURE**


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