PRODUCTIVITY OF FOREIGN COMMON WINTER WHEAT CULTIVARS (Triticum aestivum L.) UNDER THE CONDITIONS OF DOBRUDZHA REGION

ABSTRACT

One of the main directions in common winter wheat breeding is toward achieving high results with regard to yield and production potential. An important prerequisite for this is the including in breeding of new gene plasma with variable origin adequate to the growing environments and the desired goal.

The aim of this investigation was to study the productivity and the elements of yield of foreign winter wheat cultivars under the conditions of Dobrudzha region.

The investigation was carried out during 2011 – 2013 in the trial field of Dobrudzha Agricultural Institute (DAI). Twenty-four cultivars of foreign origin were tested. Their yield was compared to two standards: Enola and Sadovo 1. The cultivars were planted in harvest plots each of 10 m² in two replications. The structural elements of yield were analysed, as well as some traits and properties characterizing the variation of the separate wheat cultivars. The following traits related to productivity were investigated: vegetation period, plant height yield, number of productive tillers, grain weight per spike, number of grains per spike and 1000 kernel weight. Cultivars Kantata, Sonata, Sixtus and Podoima demonstrated highest production potential realizing a yield of more than 8 t/ha, averaged for the three years of investigation. Highest variation was observed in the traits grain weight per spike and number of grains per spike. The above mentioned genotypes are suitable cultivars which can be successfully involved in the breeding program of DAI with regard to the index yield.

Keywords: winter wheat, productivity, elements of yield.

INTRODUCTION

Breeding of common winter wheat is a process related to the development of new cultivars with optimal combination of different valuable biological and economic properties (Panayotov, 1992; Panayotov, 2013).

One of the most important directions is toward higher grain yield (Tsenov et al., 2009). The use of initial breeding material of variable origin is a
good prerequisite for achieving the set goals. The investigations on the productivity of foreign bread wheat cultivars would give important information whether they could be involved in the breeding programs of Dobrudzha Agricultural Institute (DAI) (Stoeva et al., 2009; Tsenov, 2013). Grain yield is a value, which is not only genetically determined but also dependent to a high degree on the growing conditions (Tsenov et al., 2006; Tsenov et al., 2014; Sabaghnia at al., 2013). Many materials need to be preliminary adapted before they could be included in the process of hybridization. Measuring the separate elements, which influence the formation of productivity and their variation during the different years, would help to make the proper selection of parental forms (Chamurlyiski et al., 2012).

The aim of this investigation was to study the productivity and the elements of yield of foreign common winter wheat under the conditions of Dobrudzha region.

**MATERIAL AND METHODS**

The experiment was carried out during 2011 – 2013 in the trial field of DAI. Twenty-four varieties of foreign origin were tested (Table 1). Their biological and economic properties were compared to two standards, Enola and Sadovo 1, which are national models for quality group B within the system of the Bulgarian Executive Agency of Variety Testing, Field Inspection and Seed Control.

Table 1. Common winter wheat cultivars used in this investigation

| Varieties | Origin     | Varieties | Origin     |
|-----------|------------|-----------|------------|
| Dobropolka| Balti, Moldova | Lilyana   | Novi Sad, Serbia |
| Liman     | Balti, Moldova | Dragana   | Novi Sad, Serbia |
| Podoima   | Balti, Moldova | Kantata   | Novi Sad, Serbia |
| Livada    | Balti, Moldova | Sonata    | Novi Sad, Serbia |
| Harry     | USA        | Kiria     | Odessa, Ukraine |
| Wesley    | USA        | Vesta     | Odessa, Ukraine |
| Cougar    | USA        | Zmina     | Odessa, Ukraine |
| Yuamar    | USA        | Kolumna   | Odessa, Ukraine |
| New Sky   | USA        | Cornelius | Austria     |
| Prowers   | USA        | Sixtus    | Austria     |
| Jerry     | USA        | Faur      | Fundulea, Romania |
| Sadovo 1  | BG - check | Glosa     | Fundulea, Romania |
| Enola     | BG - check | Boema     | Fundulea, Romania |

The cultivars were planted in harvest plots each of 10 m² in two replications, according to the Latin square method, at sowing norm 500
germinating seeds/m². Planting was done within the optimal dates after previous crop grain pea.

The structural elements of yield were analysed, as well as some traits and properties characterizing the variation of the individual wheat cultivars. The vegetation period (DH) was represented as number of days from January 1st till the date to heading. Plant height (PH, cm) was recorded at stage milk maturity. The following traits related to productivity were investigated: yield (t/ha) – GY; number of productive tillers (number of stems per m²) – NPT; 1000 kernel weight (g) – TKW. The following indices were calculated: grain weight per spike (g) – WGS, number of grains per spike – NGS.

The mathematical processing of data was done with EXCEL 13. Dispersion, variation, correlation and PC analyses were the applied statistical approaches, using the software SAS 9.1, XLSTAT 7.5.2 and BioStat 6.0.

Year 2013 was most favourable for the development of common wheat with respect to the meteorological conditions. The investigated materials realized to a large extent their production potential in spite of the lower-than-the-norm precipitation during April-June. The rainfalls, however, were sufficient during a stage optimal for the development of the plants. The results related to productivity of wheat in 2011 and 2012 were lower, especially during 2011. On the whole, the conditions during these two years had some negative effect on the development of the crops and the formation of yield.

**RESULTS AND DISCUSSION**

The results from the trial, averaged for the three years, are summarized in Table 2. Concerning the vegetation period, none of the investigated cultivars differed significantly from the standards Enola and Sadovo 1. Maximum levels of plant height (PH) were recorded in the wheat varieties Sixtus, Jerry, New Sky and Cougar – over 100 cm. The obtained values of this parameter showed that the tested genotypes with origin from USA exceeded the standards. A similar tendency was observed also for the trait number of productive tillers per m² (NPT). Highest values were read in the cultivars New Sky and Yuamar. With regard to weight of grains per spike (WGS), cultivar Podoima exceeded the rest of the varieties with weight of 1.5 g. The investigated accessions formed lower weight of grains per spike in comparison to the standard Enola, approximating more the standard Sadovo 1. Highest number of grains per spike (NGS) was recorded in cultivar Vesta, and Sadovo 1 demonstrated maximum absolute weight (TKW); none of the investigated materials exceeded the standard by this index. Most of the wheat cultivars were at the level of Enola. In general, the fourteen cultivars exceeded the standards by grain yield (GY) at the highest level of significance. Maximum results with regard to productivity were recorded in the Serbian accessions Kantata and Sonata which realized 8.65 t/ha and 8.54 t/ha, respectively. The other two cultivars, which exceeded all other investigated varieties, were the Austrian Sixtus and the Moldovian Podoima. The calculated variation coefficient showed that there was highest variation in the traits weight
of grains per spike (WGS), number of grains per spike (NGS) and plant height (PH). This variation was due to the fact that the materials involved in this investigation were of various origins and their response to the environment was most clearly expressed in these parameters.

Table 2. Grain yield, vegetation period and structural elements of yield

| Cultivars          | DH   | PH   | NPT  | WGS  | NGS  | TKW  | GY   |
|--------------------|------|------|------|------|------|------|------|
| Dobropolka         | 135.5| 73.8 | 574.3| 1.32 | 28.7 | 46.3 | 7.50***|
| Liman              | 137.7| 78.3 | 610.7| 1.20 | 24.8 | 49.2 | 7.32  |
| Podoima            | 136.0| 89.3 | 553.3| 1.50 | 31.1 | 48.4 | 8.16***|
| Livada             | 139.2| 81.8 | 549.3| 1.44 | 28.9 | 49.8 | 7.76***|
| Harry              | 138.0| 89.7 | 634.7| 1.11 | 27.7 | 40.1 | 6.93  |
| Prairie red        | 131.8| 84.3 | 747.7| 0.93 | 21.8 | 43.2 | 6.95  |
| Cougar             | 135.7| 104.3| 708.3| 0.95 | 21.0 | 46.0 | 6.73  |
| Yuamar             | 134.5| 87.5 | 771.0| 0.95 | 26.3 | 37.1 | 7.39  |
| New Sky            | 136.5| 106.3| 781.3| 0.87 | 24.4 | 35.7 | 6.67  |
| Jerry              | 136.7| 108.8| 656.7| 1.01 | 22.3 | 46.0 | 6.70  |
| Cornelius          | 139.0| 98.0 | 581.3| 1.29 | 28.0 | 46.3 | 7.44***|
| Sixitus            | 140.7| 109.8| 651.3| 1.29 | 29.6 | 43.7 | 8.26***|
| Lilyana            | 133.3| 87.0 | 619.7| 1.05 | 21.7 | 48.9 | 6.53  |
| Dragana            | 133.3| 91.7 | 708.7| 1.05 | 20.2 | 52.3 | 7.45***|
| Kantata            | 136.2| 87.8 | 651.7| 1.32 | 29.2 | 45.7 | 8.65***|
| Sonata             | 134.8| 85.7 | 744.3| 1.14 | 23.7 | 48.6 | 8.54***|
| Kiria              | 135.7| 72.0 | 656.7| 1.20 | 24.1 | 50.3 | 7.94***|
| Vesta              | 136.3| 81.2 | 535.0| 1.47 | 31.4 | 47.0 | 7.99***|
| Zmina              | 134.8| 79.5 | 518.7| 1.31 | 28.9 | 45.8 | 6.84  |
| Kolumna            | 135.3| 96.3 | 636.7| 1.19 | 25.6 | 47.2 | 7.60***|
| Faur               | 135.5| 80.2 | 597.3| 1.28 | 26.7 | 47.9 | 7.59***|
| Glosa              | 133.5| 81.8 | 597.7| 1.31 | 25.3 | 52.2 | 7.85***|
| Boema              | 134.8| 81.0 | 604.0| 1.28 | 27.1 | 47.7 | 7.71***|
| **Sadovo 1 BG check** | **133.8** | **92.5** | **596.0** | **1.20** | **22.1** | **54.3** | **7.02** |
| **Enola BG check** | **132.2** | **77.2** | **530.0** | **1.35** | **28.0** | **48.9** | **7.15** |
| **Mean**           | 135.6| 88.2 | 632.7| 1.2  | 25.9 | 46.7 | 7.5   |
| **Standard Error** | 0.43 | 2.13 | 15.16| 0.03 | 0.65 | 0.86 | 0.12  |
| **VC%**            | 1.58 | 12.05| 11.98| 14.42| 12.50| 9.24 | 7.94  |

*** - p ≤ 0.01

LSD5% - 0.14; LSD1% - 0.19; LSD0.1% - 0.24
The dispersion analysis was performed according to the following model:

\[ Y_{ijk} = Y_\cdot + G_i + Y_j + (GY)_{ij} + E_{ijk}, \]

where \( G \) and \( Y \) were the factors genotype and climatic conditions, and \( E \) was the error of the model.

The results are presented in Table 3. All interactions were significant. Highest was the effect of the year on the vegetation period (DH), the number of productive tillers per m² (NPT) and productivity (GY). The effect of the genotype was clearly expressed only on plant height (PH). The interaction between the genotype and the environment was very strong in the parameters number of grains per spike (NGS) and weight of grain per spike (WGS), which explains the results in Table 2 and is the reason for their strong variation. It can be concluded that the above structural elements of yield in the tested materials varied over years under the effect of the respective meteorological conditions; in some of the indices a constant regularity prevails which is genetically determined. This is a normal response because the investigated materials are not adapted to the environment in which the experiment was carried out.

| Index  | Genotype | Year | Genotype*Year |
|--------|----------|------|---------------|
|        | MS       | F-value | F% | MS       | F-value | F% | MS       | F-value | F% |
| DH     | 27.4     | 37.1   | 10.0 | 2882.9   | 3895.8  | **87.7** | 2.0  | 2.7 | 1.5 |
| PH, cm | 678.2    | **40.9** | 60.8 | 3891.5   | 235.0   | 29.1  | 30.8 | 1.9 | 5.5 |
| NPT    | 34489.8  | 10.7   | 33.5 | 497022.6 | 154.4   | **40.2** | 8563.5 | 2.7 | 16.6 |
| WGS, g | 0.2      | 13.8   | 44.7 | 1.1      | 85.7    | 23.1  | 0.1  | 3.4 | **22.1** |
| NGS    | 63.1     | 7.2    | 31.8 | 797.4    | 90.7    | 33.5  | 20.8 | 2.4 | **20.9** |
| TKW, g | 111.9    | 30.5   | 53.6 | 774.1    | 211.1   | 30.9  | 10.4 | 2.8 | 10.0 |
| GY, t/ha | 2.1 | 32.0 | 12.8 | 152.6 | 2313.1 | **77.0** | 0.7  | 11.3 | 9.0 |

Table 4 summarizes the correlation coefficients of yield with the structural elements which form it. The productivity of the investigated foreign common winter wheat varieties was formed mainly by the weight of grains per spike (WGS) and the number of grains per spike (NGS). A non-significant negative correlation was observed between productive tillering (NPT) and yield (GY). This is not a typical correlation, but its negativity is in this case caused by the cultivars with origin from the USA, which had high number of spike-bearing stems per m² but formed low yield because low values of the index weight of grains per spike (WGS) were observed in them. Another explanation could be the significant high negative correlation (r = -0.85) between productive tillering (NPT) and weight of grains per spike itself (WGS). Such an approach for investigating the production potential of foreign materials in Bulgaria has been applied to other crops as well (Georgiev et al, 2009).

The cultivars already mentioned in Table 2 which realized higher yield, formed their productivity as a result from optimum combination of productive
tillering (NPT) and 1000 kernel weight (TKW) – this was the case with the first genotype (cultivar Sonata); in cultivar Kantata this was mainly due to the high number of grains per spike (NGS) – 29. These correlations have been confirmed by other authors investigating Serbian breeding (Protic, et al., 2010), too. There is a specific peculiarity observed in the Bulgarian standard cultivars – low number of productive tillers per m², which is compensated for by the high number of plump grains per spike.

Table 4. Correlation analysis

|          | DH   | PH, cm | NPT  | WGS, g | NGS  | TKW, g | GY, t/ha |
|----------|------|--------|------|--------|------|--------|----------|
| DH       | 1    | 0.38   | -0.14| 0.27   | 0.46*| -0.24  | 0.26     |
| PH, cm   |      | 1      | 0.43*| -0.44*| -0.25| -0.36  | -0.23    |
| NPT      |      |        | 1    | -0.85***| -0.60**| 0.47*  | 0.59**   |
| WGS, g   |      |        |      | 1      | 0.78***| 0.50** | 0.50**   |
| NGS      |      |        |      |        | 1    | -0.18  | 0.24     |
| TKW, g   |      |        |      |        |      | 1      |          |
| GY, t/ha |      |        |      |        |      |        | 1        |

* - p ≤ 0.05 , ** - p ≤ 0.01 , *** - p ≤ 0.001

Figure 1 presents the distribution of yield and its elements as a result from the applied PC analysis. According to the Total Variance Explained, determining were the indices NGS (46.3%) and WGS (25.4%). These results are analogous to the obtained correlations in Table 4. The effect of the indices absolute weight (TKW) and plant height (PH) was insignificant. The indices number of productive tillers per m² (NPT) and plant height (PH) had first negative components but the high positive values of their second component implied indirect effect. The indices yield (GY) and vegetation period (DH) had high per cent from the variation, too. The indices NGS and DH had positive first and second components, which proved their positive effect on the formation of productivity (GY).

![Component Plot in Rotated Space](image-url)
CONCLUSIONS

– Highest yield, averaged for the three years of the investigation, was realized by the Serbian cultivars Kantata and Sonata.
– The factor year was determining for the formation of the production potential of the studied foreign wheat cultivars.
– The yield from the investigated materials was formed mainly on the basis of the high number of grains per spike and their high weight.
– Wheat cultivars Kantata, Sonata, Sixtus and Podoima can be successfully included in the breeding programs of DAI with the aim of increasing productivity.

REFERENCES

Georgiev G., Hristov, M., Piskov, A., 2009. Comparative testing of foreign sunflower hybrids in the region of North-East Bulgaria. Field Crops Studies, Vol. 5 №2 p-p: 307-314

Panayotov I., 1992. The breeding program of common winter wheat – status and future prospects. Agricultural science Vol. 30(4-6) p-p: 33-41

Panayotov I., 2013. A study on a new design of productivity in wheat (Triticum aestivum L.) Wheat – genetic and breeding researches. p-p: 724-772

Sabaghnia N., Mohammadi, M., Karimizadeh, R., 2013. Interpreting genotype x environment interaction of bread wheat genotypes using different nonparametric stability statistics. Agriculture & Forestry, Vol. 59 Issue 2 p-p: 21-35

Stoeva I., Chamurliyiski, P., Tsenov, N., 2009 Investigation on Bulgarian and foreign common winter wheat varieties and lines with a view of their using in breeding for productivity and quality. Field Crops Studies Vol. 5 №2 p-p: 253-260

Tsenov N., Kostov, K., Todorov, I., Panayotov, I., Stoeva, I., Atanassova, D., Mankovsky, I., Chamurliyiski, P., 2009. Problems, achievements and perspectives in the breeding for productivity of common winter wheat. Field Crops Studies Vol. 5 №2 p-p: 261-273

Protic R., Zoric, M., Todorovic, G., Protic, N., 2010. Seed Size of Wheat Variety Grown in Multi-Environment. Romanian Biotechnological Letters, Vol. 15 №6 p-p: 5745-5753

Tsenov N., Kostov, K., Gubatov, T., Peeva, V., 2006. Study on the genotype x environment interaction in winter wheat varieties. II. Grain yield. Field Crops Studies Vol. 3 № 2 p-p: 167-175

Tsenov N., Petrova, T., Tsenova, E., 2013 Investigation on the possibility to efficiently use Ukrainian cultivars for developing of early winter wheat lines. Agricultural Science and Technologies Vol. 5 №4 p-p: 351-357

Tsenov N., Atanasova, D., Gubatov, T., 2014. Influence of environments on the amount and stability of grain yield in the modern winter wheat cultivars. II. Evaluation of each variety. International Plant Breeding Congress. Abstract book. 10-14 November 2013 Antalya, Turkey p-p 132

Chamurliyiski P., Tsenov, N., Stoeva, I., Doneva, S., 2012. Economic characteristics of some foreign common winter wheat cultivars (Triticum aestivum L.). Plant breeding sciences, Vol. 5 №49 p-p: 13-17