Italian Journal of Agronomy
A Journal of Agroecosystem Management
Official Journal of the Italian Society for Agronomy

https://www.agronomy.it/

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Please cite this article as doi: 10.4081/ija.2023.2194

Submitted: 24/01/2023
Accepted: 21/06/2023

Phenotypic marker study of worldwide wheat germplasm

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Key words: correlations, phenotypic, variability, wheat, yield components.

Acknowledgements: The Ministry of Education, Science and Technological Development (Grant no. 451-03-68/2022-14/200032) of the Republic of Serbia financially supported this research. This work was done as a part of activities of Center of Excellence for Innovations in Breeding of Climate Resilient Crops - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad, Serbia.

Contributions: All authors contributed equally.

Declaration of interest statement; We confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed.

HIGHLIGHTS

- Correlation analysis showed significant positive connections between yield and grain weight per spike. Also, heading time had positive correlation with plant height.
- A negative correlation occurred between plant height and yield, as well as between heading time and grain yield.
- Principal component analysis confirmed that the varieties Apache, Pobeda, and Svilena were the most successful with the components that are closely related to achieving high yields

ABSTRACT

The goal of this research is to test breeding material of different geographical origin, and material that is adapted to different agro-climatic regions. This research examines how different wheat genotypes behave in the climatic conditions of the Pannonian Plain, where environmental stress occur more and more frequently. Fifteen divergent wheat genotypes were evaluated for grain yield, heading time and yield components (spike length, grain weight per spike and plant height) across seasons 2017/2018, 2018/2019 and 2019/2020. By applying the ANOVA model, significant differences between tested traits were recorded among the analyzed genotypes. Among the genotypes there was a variability that ranged widely for all tested traits. The coefficient of variation ranged from 5.48% for plant height to 41.03% for grain weight per spike. Correlation analysis showed strong positive relationships between grain yield and grain weight per spike ($r = 0.87$), as well as between plant height and heading time ($r = 0.65$). Principal Component Analysis (PCA) was also applied in order to determine the differences between wheat genotypes. This yield marker study, which was carried out in the Western Balkans, could be very valuable in providing breeders with the information they need to evaluate their breeding programs.

INTRODUCTION

Increasing world population urges for provision of enough food for to human race. Global climate change is marked by increases in average annual temperature, drought stress, moisture stress, rising levels of pollution, and frequent outbreaks of crop diseases and pests, most of them concurring (Tadesse et al., 2019). Wheat is a major and versatile field crop, contributing importantly to the nutrient supply of the global population and showing wide adaptation to diverse agro-ecological conditions and cropping technologies (Mladenov et al., 2021).

One of the main goals in plant breeding is to create uniform varieties and, reduce the interaction between the created genotype and environment. Due to the global climate change, stressful environmental conditions are becoming common thus the plasticity, GEI and diversity of the individual yield-related agronomic traits are becoming increasingly important for obtaining stable grain yield per unit area. In the process of identifying the sources of variation, the total phenotypic variance could be partitioned into variance due to genotype influence, environment influence, their interactions, errors, and variance that had no agronomic explanation (Ljubičić et al., 2021). Genotype × environment interaction produces many different phenotypes, where variation is produced by the combined effects of genotype and environment. Their interaction is defined as the difference between phenotypic value and value expected from the appropriate genotype and environmental values. Understanding the causes of the genotype × environment interaction is important to identify superior genotypes. It often happens that there are difficulties in determining the genotypic performance across environments, and the cause is mainly numerous tests of many traits in several localities and seasons (Mladenov et al., 2012).

Genetic wheat diversity has the main role in breeding success, improvement, and increasing genetic yield potential. Genetic variability is a basic prerequisite in creating a visible and successful breeding program, and is essential for adaptation to new environmental changes. Genetic variability is different from genetic variation, which is the actual amount of phenotypic variation seen in a particular population. (Balkan, 2018; Wani et al., 2018). For wheat breeding to be successful, it is necessary to know the interrelationship of a large number of components which together affect the yield and quality. The change in yield components directly affects the grain yield, because the yield is a cumulative output of separate contributions of each of the components. The degree of association between these components is important for wheat breeding programs, considering the existence of interrelationship between traits. Therefore, the selection of one trait can cause changes in another trait. Quantitative grain traits depend on genetic factors, environmental factors, and their mutual interaction (Ayranci 2020). This study aims to examine the phenotypic variability of heading time, grain yield and its components, to determine the correlation degree of wheat yield components and to group and visually present the relationship between selected wheat varieties using the multivariate analysis method.

MATERIALS AND METHODS

Plant material

Fifteen divergent wheat (*Triticum aestivum* L.) cultivars, namely Acciaio, Ai-bian, Akteur, Apache, Caheme 71, Florida, Mironovskaya 808, Nizija, Norin 10/Brev.14, NS 55-25, Pobeda, Red Coat, Sava, Svilena, Triple Dirk B (Table 1), were selected with the intention to cover the time period after World War II until today, and to originate from different parts of the world.

Table 1. Name, origin, year of production and pedigree of examined wheat genotypes

Genotype	**Country**	**Year**	**Pedigree**
Acciaio	Italy	1970	Mara,ita//Mara,ita/0,10
Ai-bian	China	N/A	Tom-Thumb/?
Akteur	Germany	2004	87-308/Astron//Astron
Apache	France	1998	Axial/NRPB-84-4233
Cajeme 71	Mexico	1971	Ciano-67(sib)/3/Sonora-64/Klein-Rendidor//(sib)Siete Cerros-66;Ciano-67(sib)//Sonora-64/Klein-Rendidor/3/II-8156
Florida	USA	1984	N/A
Mironovskaya 808	Ukraine	1963	(T)Artemovka
Nizija	Serbia	1979	Argelato/KS-56-R-386//2*Bezostaya-1/3/NS-422;T-22,ita/KS-56-R-386/Bezostaya-1/NS-435
Norin 10/Brev. 14	USA	N/A	Norin10/Brevor
NS 55-25	Serbia	1985	Novosadska-Crvena/Panonija
Pobeda	Serbia	1990	Sremica/Balkan,yug
Red Coat	USA	1960	Suprresa(P1-193833)/(CI-11845) Fultz//PO-4126-A-9-32-2-2
Sava	Serbia	1967	Fortunato*2/(CI-13170) Red Coat
Svilena	Bulgaria	1994	Super-Zlatna/863-A-31//76-24-5
Triple Dirk B	Australia	1970	Winter-Minflor/n*Triple Dirk; Winter-Minflor/3* Triple Dirk

Experiment design

The cultivars were tested across seasons 2017/2018, 2018/2019 and 2019/2020 in the region of Western Balkan, on the experimental station of the Institute of Field and Vegetable Crops, Rimski Šančevi, Serbia. Wheat was sown in October 2017, 2018 and 2019 in three replications in a completely randomized design. The size of the plot was 2 m^2, and the sowing density was 550 germinating grains per square meter. The experiment was set on the soil type of chernozem, where the soybean was the previous crop. Before sowing, complete agricultural practices were applied, which includes fertilization with 50 kg nitrogen per ha, 60 kg phosphorus per ha and 60 kg potassium per ha. Later in the spring, another 50 kg nitrogen per ha in the form of ammonium nitrate was added. In April, the crop was treated with herbicides and insecticides, and weeds were removed by hand as needed. The harvest was carried out in the optimal time, July 2018, 2019 and 2020 at the stage of physiological maturity.

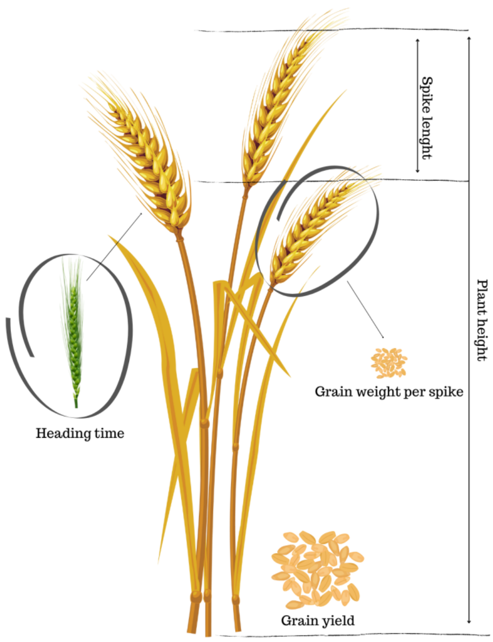


Figure 1**.** Illustration of wheat plant and analyzed traits across year 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia.

The heading time was recorded as the number of days from 1 January until the date when spikes emerged on 50% of plants on the plot. Plant height was measured as a length of plant from the bottom of the stem to the tip of the spike, excluding awns or scurs. Samples were formed by selecting ten representative spikes, which are later analyzed for the following traits: grain yield, spike lengt and grain weight per spike (Figure 1). In this study tested elite genotypes were: Acciaio, Ai-bian, Akteur, Apache, Cajeme 71, Florida, Mironovskaya 808, Nizija, Norin10/Brev.14, NS 55-25, Pobeda, Red Coat, Sava, Svilena, Triple Dirk B.

Statistical analysis

For the data obtained from the experiment, the following parameters were calculated: mean, minimum, maximum value, coefficient of variation and standard deviation. Also, analysis of variance (ANOVA), correlation coefficient and Principal Component Analysis (PCA) were calculated. In order to compare the mean values of the examined traits, the Duncan test of multiple comparisons was applied. The degree of the linear relationship between two variables was measured with Pearson's coefficient and the degree of the correlation was estimated by the scale proposed by Dawson and Trapp (2014). In order to reduce the data dimensionality, a multivariate PCA model was applied. The analyses were done in the software system STATISTICA version 14 (www.statsoft.com) while the program R, version 4.2.0 (www.r-project.org), was used for the graphical display of data.

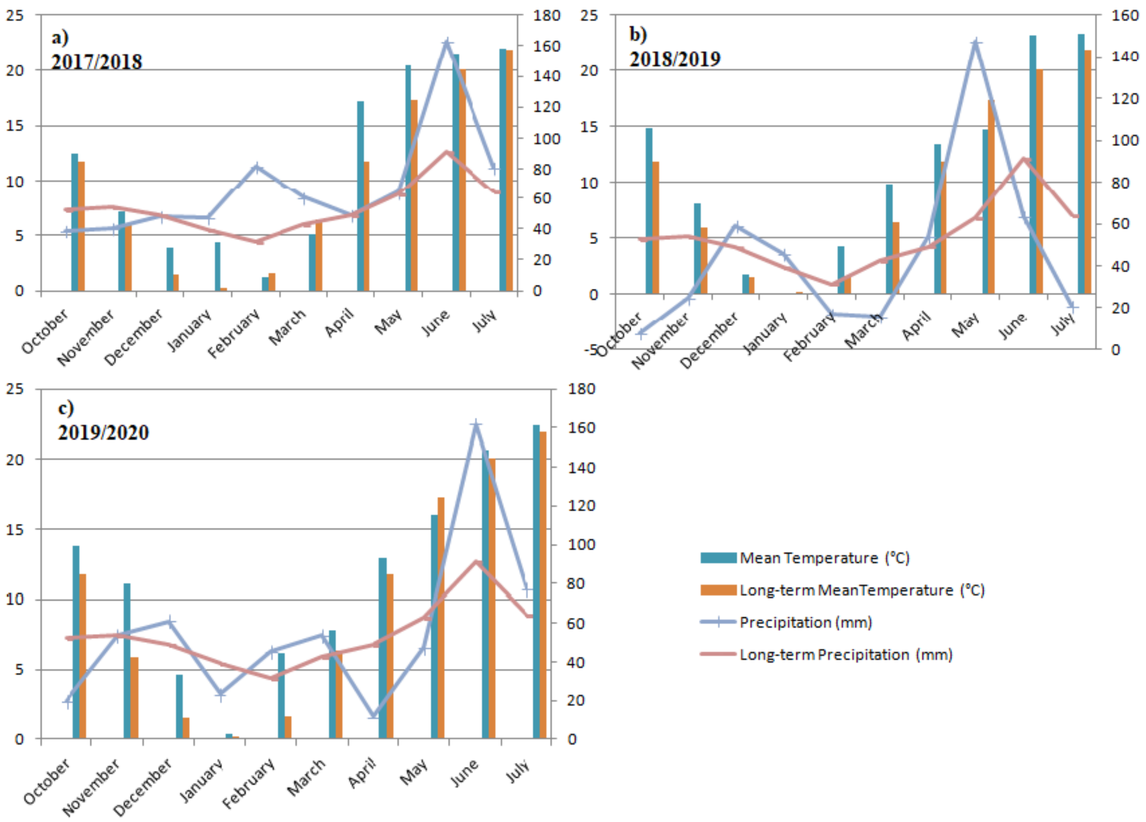
Growing season conditions

The meteorological elements of the site were obtained from the electronic publications "Meteorological Yearbook-Climatological Data", of the Republic Hydrometeorological Institute of Serbia. The average annual air temperature in the season 2017/2018 was 11.5 °C while the total amount of precipitation was 675.1 mm (Figure 2a). October precipitation significantly improved humidity of deeper layers of agricultural land (39.9 mm), and also allowed uniformly wheat germination. During the winter, the snow cover was important as protection of winter crops from low temperature, and later its melting affected the improvement of moisture reserves in the deeper layers of soil. By mid-May, air temperatures were mostly above the perennial average for May, with a measured average air temperature of 20.4 °C compared to the multi-year average for this month of 17.3 °C, which led to a further acceleration of the flow of wheat phonological stages. At the experimental site where the trial was conducted, there were unfavorable humidity conditions, due to deficit of water in the surface and deeper layers.

The beginning of growing season 2018/2019 characterized significantly warmer weather than usual and without significant amounts of precipitation (Figure 2b). The average temperature in October was 14.8 °C which is 3 °C more than the multi-annual average for this month. The very end of January and the whole of February were characterized by warmer weather with less precipitation. Warmer weather than usual did not interfere wheat dormancy. The changeable and warmer weather than the average marked April and the beginning vegetation period. The average temperature was 13.4 °C while the long-term mean temperature was 11.8 °C. During May, the maximum and minimum daily temperatures were usually below or about a long-term average. This month was significantly characterized by precipitation, when a total of 147.6 mm of rain was measured, which is twice as much as long-term precipitation. The average annual air temperature in the season 2018/2019 was 11.3 °C while the total amount of precipitation was 456.2 mm.

As in the previous two seasons, the beginning of 2019/2020 was exceptional warm weather (13.8 °C) for this time of year with significantly less precipitation (20 mm) than usual for this one period of time (Figure 2c). The total amount of precipitation for the growing season 2019/2020 was 554.6 mm, which is almost the same as long-term precipitation (536.2 mm). The average air temperature was 11.6 °C. During the whole autumn and winter, the average monthly air temperatures exceeded the long-term average. In June, the amount of precipitation significantly exceeded the values typical for this month, so a total of 161.9 mm of precipitation was measured.

Figure 2. Mean and long-term mean temperature and precipitation values for growing seasons 2017/2018, 2018/2019, 2019/2020 on Rimski Šančevi, Serbia.



RESULTS AND DISCUSSION

Descriptive statistic and analysis of variance

To identify genotypes ideal for production, researchers must test as many genotypes as possible under various conditions and treatments over several years on various environments due to different genotype reaction to environmental conditions and genotype by environment interaction.Yield as a complex trait depends on several components that together affect its expression, height, and stability. It is the result of the interaction of biotic and abiotic factors that affect the entire population, but also each individual separately. Wheat yield potential is the result of the influence of region, year of production and other sources of variation (Khan and Mohammad, 2018). One way to improve wheat selection is to reduce and control the genotype × environment interaction because, plants would react less to the ecological growing conditions. The first method to solve this problem would be to divide heterogeneous growing regions into sub-regions, and the second method to select genotypes with better stability in wider areas of cultivation (Banjac, 2015).The results of this study indicate a wide range for the values for grain yield from 1.78 t/ha to 10.35 t/ha (Table 2). The lowest yield was achieved by the variety Nizija with an average value of 3.20 t/ha, and the most productive proved to be the Apache variety, were an average yield of 9.05 t/ha was recorded. An important indicator of data dispersion is the coefficient of variation, which in this study was 23.99% which is largely significant variability between genotypes. Similar value obtained Jocković et al. (2014) analyzing 20 winter wheat genotypes of different origin during two vegetation seasons as well as Ali et al. (2008) and Nukasani et al. (2013).

Table 2. All genotypes descriptive statistic for tested traits (GY (t/ha) - grain yield, PH(cm) - plant height, SL (cm) - spike length, HT (days) - heading time, GWS (g) - grain weight per spike)

Tested traits	Min. value	Mean value	Max. value	Coefficient of variation (%)	Standard deviation
HT	120	131	150	5.48	7.19
SL	5.00	10.21	15.30	18.42	1.88
PH	66.00	98.42	166.00	23.47	23.10
GY	3.00	7.32	10.35	23.99	1.76
GWS	0.58	1.89	4.00	41.02	0.77

The analysis of variance showed significant differences among genotypes for grain yield (Table 3). These data are following the research of several authors: Devesh et al. (2018), Atiq et al. (2018), and Tarakanovas and Ruzgas (2006). In contrast to other traits, genotype × year interaction for GY was not significant.

Table 3. ANOVA (Analysis of Variance) resultes of world wheat genotypes and analyzed traits (GY (t/ha) - grain yield, PH (cm) - plant height, SL (cm) - spike length, HT (days) - heading time, GWS (g) - grain weight per spike) across years 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia.

		GY		**PH**		**SL**		**HT**		**GWS**	
Source of Variation	DF	SS	P	SS	P	SS	P	SS	P	SS	P
Genotype	14	374.50	0.0*	60639	0.0*	238.20	0.0*	3513	0.0*	23.16	0.0*
Year	2	20.75	0.0*	2691	0.0*	37.63	0.0*	2936	0.0*	19.84	0.0*
Genotype ×Year	28	15.07	0.18	7252	0.0*	71.34	0.02*	458	0.0*	23.67	0.0*
Error	90	37.23		929		126.90		18		13.75	
Total	134	447.50		71510		474.10		6925		80.48	

*statistically significant difference between genotypes (P<0.05)

Plant height is one of the essential yield components and depends on the set of major *Rht* genes, but also on a large number of minor genes distributed on all chromosomes of the wheat genome. With the introduction of semi-dwarf Japanese wheat varieties, stem height has been significantly reduced from about 130 cm in old varieties, to about 60-90 cm modern intensive varieties. The occurrence of semi-dwarf genotypes increased the interaction between the genotype and the environment (Banjac, 2015; Ljubičić et al., 2021).The average value for this trait was 98.42 cm. The variety with the longest stem was Mironovskaya 808, while the lowest was measured in genotype NS 55-25. The coefficient of variation was significant and amounted to 23.47%. Several authors confirmed the high variability for this trait, so Arya et al. (2017) stated that the coefficient of variation was 38.89%. By applying analysis of variance, statistical significance for a given trait for both levels of significance was confirmed (Table 3). Several authors, Kumar et al. (2013), Nukasani et al. (2013), Kaddem et al. (2014), cite results that support this claim.

Spike length has no direct impact on grain yield because it depends on the number of spikelets, number of grain per spikelets and number of grain per spike, and is highly correlated with these components (Ljubičić et al., 2021). Longer spikes have a larger surface area for photosynthetic activities and consequently become an important source in the collection of assimilates, which reflects on plant production. Wheat spike together with axis has a specific structure that allows it to stay longer green and functional. Due to these spike characteristics, the contribution is on average 40-50% of the dry matter that accumulates in the grain (Zečević et al., 2014; Mladenov et al., 2019).

The shortest spike was 5 cm long, while the longest spike is measured for the cultivar Mironovskaya 808, 15.30 cm long. The average value of this trait was 10.21 cm. By applying the ANOVA model, statistically significant differences were confirmed for both levels of significance. These results comply with the research of Kumar et al. (2013), Kaddem et al. (2014) and Çifci (2012).

Heading time is one of the indicators of the suitability of wheat varieties to different environments, where frost, high temperatures and drought stress are present. Rise of the average temperature by 2.0-4.9°C until the end of 21^{st} century due to climate changes will further disturb quality wheat's high and stable production. Frequent dry periods, heat stress, and heavy rainfall will become more frequent occurrences, especially in the Pannonian region. This trait was influenced by three groups of genes responding to average temperatures (earliness *per se*, *EPS* gene), cold temperatures (vernalization, *VRN* gene), and day length (photoperiod, *PDP* gene). Phenology phases are a response to temperatures, day length, and the interaction of their effects (Živančev et al., 2022; Zheng et al., 2013). Wheat demands a certain day-length to promote heading. However, in wheat photoperiod insensitive alleles were detected at the *Ppd* locus that can induce heading regardless of the day length. In bread wheat, *Ppd-1* locus on the shorter arm of the group 2 chromosomes with *Ppd-D1* gene has the largest influence on heading time. In addition, photoperiod insensitivity occurs together with Ppd-B1 gene, where higher copy number variants were associated with earlier heading (Würschum et al., 2019).

The NS 55-25 genotype needed 120 days to enter the heading, while the variety Akteur had the longest period to enter heading (150 days). From all of the examined traits, heading time is the trait that had the lowest coefficient of variation, so the variability between genotypes was only 5.48%. The low coefficient was also calculated by Kaddem et al. (2014) with 6.30%. Naik et al. (2015) stated that the coefficient of variation for this trait was 9.84%. By comparing the F- table values with the values for the levels of significance 0.05, it was found that there was a statistically significant difference. These results are consistent with research conducted by Khan (2013).

Grain weight per spike is a yield component that is conditioned by the action of minor genes, apropos mutual interaction and the influence of the environment, and can be defined as a quantitative component of the phenotypic variability of wheat. Grain weight per spike is characterized by low heritability and significant phenotypic variation, which depends on the variation of environmental factors (Banjac, 2015). Grain weight per spike has a direct positive contribution to increasing grain yield, because the number of spikelets per spike as well as the number of sterile spikelets per spike are in direct relation to yield and determines it more closely than the spike length. High temperatures during the vegetation shorten the grains watering period and induce early maturation, resulting in shrinkage and low grain weight (Knežević et al., 2015). By calculating the basic parameters of descriptive statistics, it was obtained that the lowest value of this trait, only 0.58 g, was achieved by the cultivar Nizija. The maximum value had genotypes Pobeda and Cajeme 71, whose weight was 4.00 g. The highest coefficient of variation was calculated for this trait and was 41.02%. Studies that are consistent with these results are the papers by Jocković et al. (2014) and Hristov et al. (2011) where genotype variation was 30% and 21.6% respectively. Analysis of variance showed the existence of statistically significant differences between genotypes.

Figure 3 shows that varieties Apache, Pobeda and Svilena achieved the highest results and there is no statistically significant difference between them for traits GY and GWS. Variety Mironovskaya 808 achieved the highest result for traits SL and PH and compared to all other genotypes achieved a statistically significant difference. The most different groups were formed for HT, and the variety with the longest time of heading was Akteur.

Figure 3. Duncan test for all tested traits of wheat cultivars across years 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia.

*the same letters next to different genotypes indicate that there is no statistically significant difference between them

Correlation among analyzed traits

Analysis of traits that have a potential impact on yield increasing requires determining the correlation between them. A very strong positive correlation (Figure 4.) was observed between grain weight per spike and yield (r = 0.87), and between heading time and plant height (r = 0.65). A strong negative value occurred between heading time and yield (r = -0.67) and grain weight per spike and heading time (r = -0.70), while moderate negative correlation was calculated between grain weight per spike and plant height (r = -0.50). No significant correlation was observed between heading time and spike length. The results of the correlation analysis showed that heading time did not have a positive effect on the yield itself as well as on its components which directly affect its overall increase, while with the spike length it was a very weak relationship with almost no relationship between them. Many research showed that in the Serbian agro-climatic region early varieties had higher yields. This is explained by the drought and temperature stress escape, in the summer period in the Southeast Europe (Snape et al., 2001). For these reasons during the wheat selection process genotypes that mature earlier were favored, which is consistent with the results of Trkulja et al. (2019). In their research conducted at the site of Rimski Šančevi, it was found that wheat varieties originating from region of Southeast Europe had an average value of heading time of 136.80 days, while genotypes from Western Europe achieved an average value of 143.10 days. The agro-climatic conditions of Western Europe in the summer period are characterized by lower temperatures with higher humidity, which leads to later maturation.

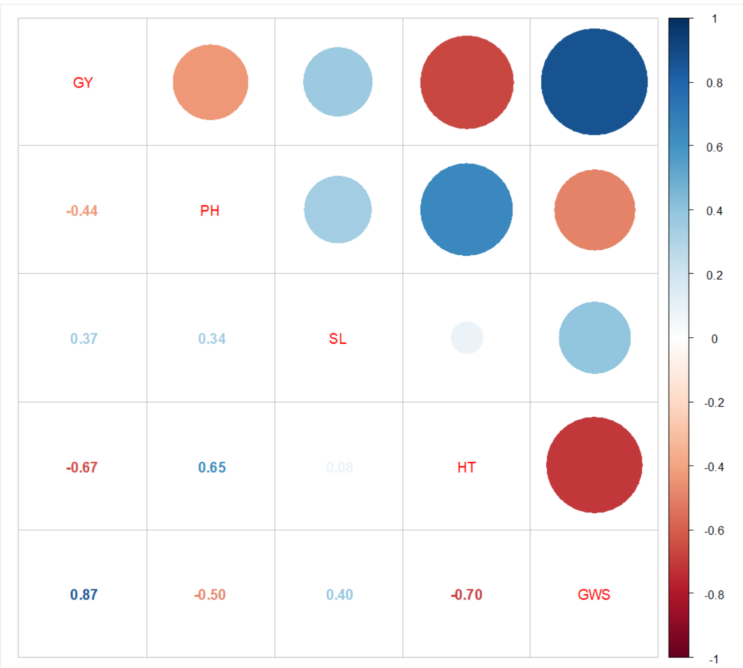


Figure 4. Graphical presentation of correlation analysis for all tested traits (GY - grain yield, PH - plant height, SL - spike length, HT - heading time, GWS - grain weight per spike) of wheat cultivars across years 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia. A smaller circle indicates weak correlation, while a larger one indicates a stronger correlation between traits.

Hristov et al. (2011) cited data in which yield is significantly correlated with grain weight per spike and where the correlation coefficient was as high as 0.97, while with spike length and plant height did not correlate. The same authors also stated that the grain weight per spike had no relation to the plant height and the spike length achieved a minimal correlation. A study conducted by Kaddem et al. (2014)

noted that the heading time and yield were not correlated (r = -0.03), while with spike length and plant height this trait was weakly related. Yield and spike length and plant height and spike length, as in this study, achieved non significant correlation.

Principal component analysis

In this research, only the first two components will be used to show results, because the first component includes 59.02% and together with the second component composes 87.93% of the total phenotypic variance. In addition to this, eigenvalues also indicate which components are retained, which is in this experiment for the first component 2.95, and the second 1.45 (Table 4).

Table 4. Principal Component Analysis results for all tested traits (GY (t/ha) - grain yield, PH (cm) - plant height, SL (cm) - spike length, HT (days) - heading time, GWS (g) - grain weight per spike) of wheat cultivars across years 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia, where Dim1, Dim2, Dim3, Dim4 and Dim5 are the extracted components.

	Dim1	Dim2	Dim3	Dim4	Dim5
GY	-0.90	0.26	0.04	-0.31	0.14
PH	0.69	0.60	0.39	-0.09	-0.07
SL	-0.20	0.94	-0.14	0.21	0.09
HT	0.87	0.27	-0.36	-0.22	-0.06
GWS	-0.93	0.24	-0.06	-0.01	-0.26
Eigenvalue	2.95	1.45	0.30	0.19	0.11
Variability (%)	59.02	28.91	6.05	3.87	2.14
Cumulative variability (%)	59.02	87.93	93.98	97.86	100.00

The diagram shows the two axes, Dim1 and Dim 2, in which the first two main components are composed (Figure 5). The first axis was formed under the influence of the values of all analyzed traits, where the results of the achieved yield and grain weight per spike contributed the most, and spike length contributed the least. In the second component, spike length had the largest contribution, while the grain weight per spike and grain yield had the lowest contribution. By further analyzing the biplot diagram, a certain arrangement of genotypes in the coordinate system is observed. Those genotypes that are in the lower half of the diagram realized below average results and those grouped in the upper part achieve high average values of analyzed traits. Those genotypes that are found around coordinate origin achieved average results.

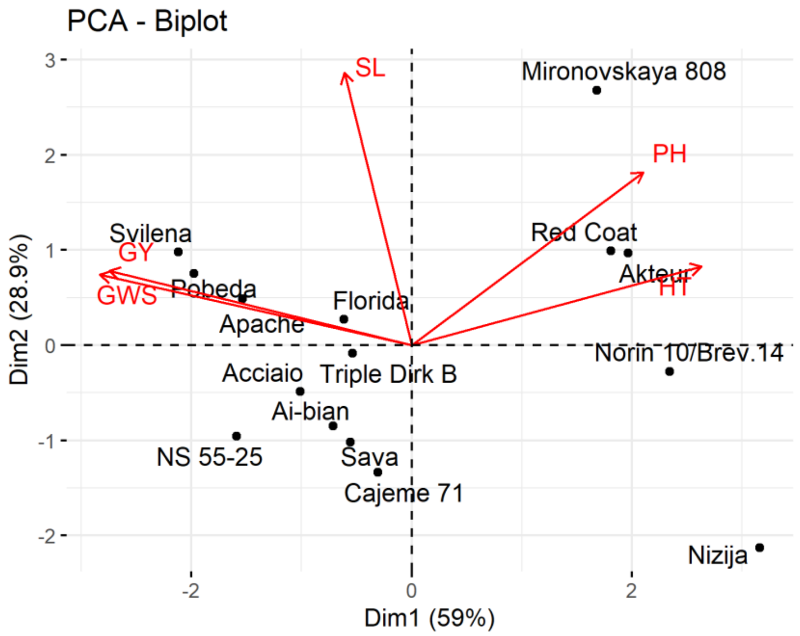


Figure 5. PCA values on the biplot diagram for all tested traits of wheat cultivars across years 2017/2018, 2018/2019 and 2019/2020 on the environment of Novi Sad, Serbia.

The varieties Apache, Pobeda and Svilena are positioned very close to the GY and GWS axes, while Nizija is the variety that is farthest in the coordinate system in relation to these two axes. These results can be explained by the time when the varieties originated, taking considering that Nizija was created in 1979, and Apache is a newer variety that has been adapted to current environmental factors. Also, Pobeda is a highly adaptable variety adapted to Serbian agro-climatic conditions and was grown on large areas.

When, it comes to the spike length vector, the closest variety is Mironovskaya 808 with a spike length of 13.01 cm and the most distant was the genotype Nizija. The closest to the plant height vector are genotypes Akteur and Red Coat, but the highest variety is Mironovskaya 808. Most days to heading had the genotypes Akteur, and opposite to them, it took the least time for the line NS 55-25 and variety Cajeme 71. In this study, there was an extremely high positive correlation between yield and grain weight per spike which is confirmed by overlapping vectors. The vectors of these two traits with plant height and heading time vectors form an obtuse angle, which is following the results of correlation analysis, where grain yield had significant negative correlation with plant height (r = - 0.44) and heading time (r = - 0.67), while grain weight per spike with plant height and heading time achieved significant negative correlation too (r = - 0.50, r = - 0.70 respectively). The spike length vector formed an approximately right angle with all other traits, while the heading time and plant height vectors formed an acute angle.

CONCLUSIONS

Among the genotypes for all tested traits there was a variability that widely ranged. The coefficient of variation was the highest at the grain weight per spike as much as 41.03%, while for the heading time was 5.48%. A significant difference for each of the traits was found. The genotypes with the highest yield values were the varieties Apache, Pobeda and Svilena. The same varieties recorded the highest values for trait grain weight per spike, which is related to the height achieved yield.

Correlation analysis showed that significant positive connections were achieved between yield and grain weight per spike and heading time and plant height. A negative correlation occurred between plant height and yield and heading time and grain yield. Principal component analysis confirmed that the varieties Apache, Pobeda, and Svilena were the most successful with the components that are closely related to achieving high yields. In this study, genotypes were examined at only one locality which means that only the influence of genotype and season on the resulting is known, while the influence of locality is unknown. For these reason, in the following research, it is necessary to include one more source of variation, to examine with greater precision the wheat varieties that will be used in a further breeding program.

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