Correlation relations and genetic distance by morphological characteristics of common wheat winter cultivars (*Triticum aestivum* L.) in South-Central Bulgaria

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Abstract
The study was conducted in Institute of Plant Genetic Resources in town of Sadovo, Bulgaria. The purpose of study is to establish traits of six common winter wheat cultivars, which can be used to identify the cultivar with morphological markers, and then the genetic difference between them will be assessed. The study period covers the vegetation season 2016/2017 to 2017/2018. According to the study by traits the length of the spike and the height of the plants studied common winter wheat cultivars falls into different groups; this makes it possible for their distinguish-ability. With the biggest effect of the genotype was characterized both traits number of kernels per spike and the height of the plants. The traits: height of plants, length of the spike and weight of thousand grains was with lowest variation by cultivars and by years. Those traits were with a significant to medium influence of the genotype, and were suitable for morphological markers. Morphological markers have to be used together, because wasn't observed proved differences of trait thousand grains weight between some of the studied cultivars. According to the dendrogram cultivar Ginra is the most distant from cultivar Nikibo.

Key words: wheat; morphological markers; cultivars; genotype; influence

INTRODUCTION

According by Lovnyaeva (2007) of a degree on variability of traits connected to the spike is strongly influenced by density of productive tillers. In unfavorable years variation is increases. For that reason is not expediently discarding in comparative testing of earlier generations for first year in elements of productivity. Discarding is right itself to by doing only trough morphological traits and visual assessment. The thousand grains weight was varying very low. The biggest was variation of number of spikes and weight of grain per experimental plots (Lovnyaeva, 2007). At 16 cultivars of wheat, was established, data of traits spike length, number of kernel in central spike and weight of grin per plant vary middle, witch have to be mention for selection of typical progeny (Desheva & Kachakova, 2013). It was found that it would be more effective for wheat to depend on nitrogenous fertilizing and crop density (Vasileva et al., 2014).

The height of the plant, the number of spikes per unit area and the thousand grains weight has a direct and strong influence on the expression of the yield (Markova & Ruzdik, 2015). The number of spikelets along the length of the spike is effective for breeding in terms of wheat grain size and spikelets fertility using the Chi-squared Automatic Interaction Detection (CHAID) growing Method grouping (Stoyanov, 2013; Saini et al., 2017). The same trait called spikelet density can be methodically defined as the number of spikelets per centimeter of spike length. It should be noted that the number of spikelets does not include those located at the base of the spike, as they are often not fertile (Guo et al., 2018). Increasing the number of kernels in spikes

can be obtained by keeping the fertile spikelets in the anthesis phase (Slafer et al., 2015). More flowers in the spikes have a positive effect on the number of kernels in the spike. They are negatively correlated with thousand grains weight. Between the weight of the grain in the spike and the number of florets in the spike, a negative correlation was found in only two studied cultivars (Koshkin, 2016).

Climate change through temperature stress negatively affects the duration and rate of grain filling. The plasticity of wheat genotypes during anthesis and fertilization, and grain filling is crucial for the formation of yield under heat stress (Abdelrahman et al., 2020). In dry climates, the shortening of the growing season, maintaining the "stay green" effect in the period of flowering-grain filling, shortening the stem and reducing productive tillering, increasing the harvest index lead to a successful breeding process for productivity (Boyadjieva, 2011; Andonov, 2012) The grouping of cultivars for studying the phenotypic variation of grain yield, as well as the changes of the phenotypic traits was carried out to establish the ecological plasticity and stability of wheat cultivars. It was performed both as a group of cultivars and individually for each cultivar (Tzenov et al., 2013).

Most German farmers recognize the impact of climate change. Experience of German producers has shown that the choice of cultivar is of the utmost importance, as integrated protection and crop rotation are the main factors for stable yield (Macholdt & Honermier, 2016; Macholdt & Honermier, 2017). The total influence of genotype and environment is greatest on grain yield per unit area. The greatest influence has the genotype on the traits-elements of yield: thousand grains weight and the number of spikelets of the central spike, the height of the central stem and the length of the main tiller (Chipilski, 2016; Dimitrov, 2017; Angelova et al., 2020). The height of the plants is the sign that is most often found in the variety descriptions (http://ipgrbg.com/). Loci of quantitative traits (QTL) are associated with agronomic and physiological traits, which serve as methods to support the breeding of highly efficient wheat genotypes (Tshikunde, 2019).

Yield is strongly positively correlated with biomass and the number of productive tillers, and has a moderately positive correlation with the total number of tillers (Hosin Babaiy et al., 2011). The authors (Budakli Carpici & Celik, 2012) claim that in wheat, the number of spikes per unit area, the number of kernels in a spike and the weight of grains in a spike has a high correlation with grain yield. The strongest correlation in common winter wheat was found in the traits weight of grins per plant and weight of grains of central spike. In barley, it was found that the traits productive tillers per unit area and weight of grain per spike have the highest direct effect on grain yield (Neykov, 2016). The influence of the trait of productive tillers on the response of the genotype is stronger than environment (Dodig et al., 2008; Gaju et al., 2009). The nature of the variability of the yield elements is determined mainly by the genetic characteristics of the cultivars. It is most pronounced in the number of productive tillers and the weight of grain per unit area. (Lovnyaeva, 2007). Morozova (2013) quoted by Signayevskiy (2014) speaks of the presence of morph-biological groups existing within a cultivar-population, from which it is possible to determine how the breeding process proceeded and to evaluate the starting material for subsequent intro-cultivar breeding.

MATERIAL AND METHOD

The experiment was carried out in the experimental field of the Institute of Plant Genetic Resources "K. Malkov" in the town of Sadovo, located in the South-Central region of Bulgaria in the period 2016/2017-2017/2018. The soil is type Pellic vertisol (FAO), medium deep (A+B horizon=60-80cm) slightly clay, with a high content of physical clay and silt fraction (Dimitrov, 2018).

The field trail was sown with elite pro-genies of common winter wheat cultivars Gaya 1, Nikibo, Ginra, Sadovo 1, Tzarevetz and Farmer. Cultivar Gaya 1 is medium-strength wheat, created by the method of inter-varietal hybridization (FD 6405/Fr/n Zg720-1 x Sadovo 1). The stem is short 70-75 cm; the spike has 46-50 grains per spike, dense, 9-10 cm long. The thousand grains weight of Gaya 1 cultivar is 48-52 g, the cultivar is medium-early with a high potential yield over 850 kg (Boyadjieva, 2007; Rachovska et al., 2012; https://agriacad.bg/). The short stem distinguishes it from the other cultivars of common winter wheat, which are cultivars maintained in IPGR (http://ipgrbg.com/).

The Nikibo cultivar was created by inter-varietal hybridization between Nika Kubani X Prelom and

an individual selection. Cultivar Nikibo is a medium-early cultivar, its heading time is same as Sadovo 1. The stem is 10 cm lower than that of the cultivar Prelom. It has a high productivity potential of 828-956 kg/da, an average of 792 kg/da from many years of testing. The spike has an average length of 10.2 cm (9.25 cm for Sadovo 1), the number of kernels in spike is 46. The weight of the grains of spike of Nikibo cultivar is 2.1 g. The thousand grains weight varies from 37.70 g to 44.96 g, on average 44.4 g. The established number of spikes stems/m² is 718. Cultivar Nikibo belongs to group B - medium with increased strength wheat. On average grain yield 674 kg/da was obtained for the test period, compared to 697 kg/da for the Enola standard cultivar (APVTASC, 2013; Andonov, 2017).

Cultivar Sadovo 1 (Jubilee x Bezostoya 1) and cultivar Tzarevetz were created by hybridization and following individual selection. The Tzarevetz cultivar is a dubble-cultivar hybrid from Zebrets x Katya, and in the Katya cultivar a parent is the Bezostaya 1 cultivar (Hebros x Bezostaya 1).

The cultivar Farmer was created by the method of experimental mutagenesis of the Pobeda cultivar (Triticum Sph. X Rotund. [(Tr. Durum x Sec. Montanum) x Bezostaya 1 x Mexico 225)]). What they have in common is that the Russian cultivar Bezostaya 1 is included in everyone's pedigree (Rachovska et al., 2012). On average grain yield (664 kg/da) was obtained from the Farmer cultivar for the test period (APVTASC, 2009), in Macedonia 507 kg/da (Ilieva et al., 2013).

The Tzarevetz cultivar in a field trial yielded 686 kg/da (APVTASC, 2008), in Macedonia 487 kg/da (Ilieva et al., 2013). Cultivar Sadovo 1 gives a grain yield of 648 kg/da in Sadovo, Bulgaria in a competitive cultivar trail 2014-2016 (Uhr, 2017). In cultivar testing at the State Agricultural Institute of General Toshevo yielding was 978 kg/da (Boyadjieva, 2007).

Cultivar Ginra was created by the method of inter-varietal hybridization by ♀Sadovo 1 X ♂Guinness/1322. In a cultivar trail of 2014-2015, the thousand grains weight varied from 33.40 to 49.55 g, with an arithmetic mean 42.51-45.00 g. The obtained results with a thousand weight grains (42.51 g) were found in 710 spike-bearing stems/m². The height of the stem is 105-110 cm, lower than the parental forms; the number of spike-bearing stems is greater than that of cultivar Sadovo 1, forming a dense crop. The length of the spike is 10 cm, the number of kernels in a spike is 36, and the weight of grains of one spike is 1.9 g. The cultivar gives 750-770 kg/da grain yield, (APVTASC, 2016; Uhr, 2017). It has a very good productive tilling and forms a dense crop. There are productive spikes that are very well grained, and its grain is large.

Sowing was done according to a scheme for comparative testing of earlier generations in the first year (G1) in the maintenance of cereals (Ministry of Agriculture and Foods Industry, 1977). The breeding of initial spikes was performed in per-basic crops. After an assessment in laboratory conditions on the spike typicality and seeds, the preparation of the sowing was started. The seeds are sown by machine, each row representing the seeds of one spike with a length of 1 m, at distances of 25-30/5-6 cm. The rows representing generation are separated by a 35-40 cm path. A 35-40 cm path is left between the 90 cm wide beds. The sowing was done on time - in October.

Bio-metric measuring performed by the guidance of Dimova & Marinkov (1999) from plants collected of quarter square meter (50x50 cm), collected spikes were threshed manually separately. Mixing spikes is not admitted. Plant height without awn (cm), number of productive tillers per m², number of kernel per spike, length of spike without awn (cm), weight of grain of spike (g), thousand grains weight (g), kernel density were reported.

The following analyzes were performed: variation analysis: the arithmetic mean with a coefficient of variation (CV%) is calculated; accuracy indicator ($Sx\bar{}$%), (Dimova & Marinkov, 1999). A dispersion analysis of the studied traits was performed with the software products SPSS 19 and JMP 5.0.1. It was presented by the power of the factors genotype, year and genotype x influence of the conditions of the year. A correlation analysis was also performed by Genchev et al. (1975) with software product SPSS 19 (SPSS Inc.) and Ward cluster analysis (SPSS 19). Morphological markers, pedigree and correlations between these markers were used to assess the genetic distance between wheat genotypes. The traits plant height, number of productive tillers per unit area, thousand grains weight, spike length and number of kernels per spike and other yield elements were used. A variation analysis with a coefficient of variation (CV%) was used to determine morphological markers. Traits that can serve as morphological

markers should have a low coefficient of variation and the strength of the genotype factor should be high (Lidanski, 2011).

The aim of the study is to determine morphological markers to identify the studied cultivars of common winter wheat and to assess their genetic difference.

RESULTS AND DISCUSIONS

1. Factor cultivar x years of study

The change of the traits of each cultivar according to the years of research is considered (Table 1). The cultivars Gaya 1, Ginra, Nikibo and Sadovo 1 have proven differences in number of productive tillers/m² and a similar trend of decreasing the number of productive tillers from the first to the second year. Cultivar Tzarevetz and Farmer have a reverse trend of increasing the number of productive tillers. The reduction of tillering (removal of tillers) changes the distribution of the photosynthetic influx of assimilates and changes the morphology of the spike (Guo et al., 2018).

The cultivars of common winter wheat Nikibo, Tzarevetz, Farmer and Ginra have a trend of increasing the height of the plants from the first to the second year. In Sadovo 1 and Gaya 1 the height of the plants has not been proven to change. In the Ginra cultivar, the height of the plants decreases from the first to the second year. The length of the spike in the cultivars Gaya 1, Tzarevetz and Ginra has a trend of proven decrease from the first to the second year. In the cultivars Farmer and Sadovo 1 the length of the spike does not change, with the cultivar Nikibo it increases, and it is possible to show tolerance to heat at elevated temperatures during anthesis.

According to Bela & Sikder (2018), thermal tolerance depends on the mechanism of heat accumulation in plants for the occurrence of a certain phonological phase. According to the same authors, heat tolerance is determined by the relationship between temperature, growth state and stage of phonological development of the culture. In the cultivar Tzarevetz and Ginra the number of kernels decreases from the first to the second year. In the cultivar Nikibo and Sadovo 1 the trend is reversed - to an increase from the first to the second year. And for the cultivar Sadovo 1 and Farmer the number of kernels in the spike is preserved during the two years of research. The trend in the cultivars Tzarevetz and Ginra in the weight grain of spike is similar and it has been proven that the trait does not change by years. In the cultivars Nikibo, Tzarevetz, Ginra and Sadovo 1 the trend in weight per thousand grains is increasing from the first to the second year. In the cultivar Gaya 1 and Farmer the thousand grains weight does not change. The cultivar Gaya 1, Tzarevetz and Ginra have a trend of increasing the kernel density. In the cultivars Sadovo 1 and Farmer the kernel density does not change. In the Nikibo cultivar, the kernel density decreases from the first to the second year.

The thousand grains weight of Ginra cultivar has the largest range by years of study (8.03 g), cultivar Gaya 1 has the smallest range of thousand grains weight between years of study (2.1 g). The Nikibo and Farmer cultivars with thousand grains weight also have a larger range of the average values between the years of research, respectively 6.06 g and 5.16 g. Tzarevetz (4.42 g) and Farmer (3.08 g) cultivars are with a slighter range on the arithmetic mean of thousand grains weight between the years of research are.

2. Factor - Cultivar

The variation by productive tillering by cultivars for the whole period of the study is the largest 22.60%. The cultivars Gaya 1, Nikibo and Tzarevetz by number of productive tillers went into the intermediate group "BC". The height of the plants is minimal in the cultivar Gaya 1 (74.5 cm). The maximum value is the height for Nikibo cultivar (87.8 cm) and Farmer cultivar (85.95 cm) for the whole period of the study. The height of the plants has the least variation in the studied wheat varieties 6.08% for the whole period of the study. The length of the spike has a minimum value (9.58 cm) for the cultivar Sadovo 1, with a maximum value of the cultivar Farmer (11.28 cm). The variation of the length of the spike by the cultivars of common winter wheat is low (6.33%). According to the length of the spike and the height of the plants, the wheat cultivars went into different groups, which allow their distinctiveness.

Cultivar Sadovo 1 has the lowest number of productive tillers m² (314), Ginra has the largest number of productive tillers of m² (479). The traits of the cultivars are considered independently by factor-cultivar and by the conditions of the years of study

Table 1. Least significant difference (LSD) trough years for every cultivar and variation coefficient (CV %) with JMP 5.0.1 of all traits

Cultivar	Year	Number of productive tillers/m^2	Plant height	Spike length	Number kernel/ spike	Weight Grains/spike	Thousand grains weight	Kernel density
Factor - Cultivar x years of study								
Gaya 1	2016/2017	468^{a}	75.3^{a}	10.7^{a}	56.9^{a}	2.85^{a}	50.76^{a}	2.70^{b}
	2017/2018	208^{b}	75.5^{a}	9.7^{b}	54.9^{a}	2.76^{a}	48.66^{a}	3.43^{a}
	LSD	21	4.91	0.56	4.41	0.32	5.33	0.25
	CV %	6.62	7.02	5.80	8.44	12.1	11.41	8.83
Nikybo	2016/2017	380^{a}	85.1^{b}	9.64^{b}	54.1^{b}	2.53^{b}	46.33^{b}	3.62^{a}
	2017/2018	264^{b}	90.5^{a}	10.55^{a}	72.4^{a}	3.79^{a}	52.39^{a}	2.82^{b}
	LSD	26.33	2.76	0.50	4.22	0.33	3.97	0.30
	CV %	8.7	3.35	5.17	7.08	11.2	8.56	10.11
Tzarevetz	2016/2017	308^{b}	75.9^{b}	10.94^{a}	78^{a}	3.28^{a}	41.44^{b}	2.67^{b}
	2017/2018	412^{a}	80.3^{a}	10.18^{b}	73^{b}	3.36^{a}	45.86^{a}	3.43^{a}
	LSD	26.65	3.15	0.50	4.55	0.33	3.12	0.21
	CV %	7.89	4.28	5.00	6.39	10.43	7.62	7.44
Ginra	2016/2017	575^{a}	78.4^{b}	10.45^{a}	54.0^{a}	2.801^{a}	48.83^{b}	2.76^{b}
	2017/2018	384^{b}	86.0^{a}	9.29^{b}	50.0^{b}	2.800^{a}	56.03^{a}	3.84^{a}
	LSD	26.94	3.78	0.33	2.79	0.31	5.19	0.20
	CV %	5.98	4.90	3.52	5.73	11.75	10.53	6.45
Sadovo 1	2016/2017	356^{a}	84.4^{a}	9.77^{a}	44^{b}	2.18^{b}	49.68^{b}	3.34^{a}
	2017/2018	272^{b}	85.7^{a}	9.39^{a}	50^{a}	2.71^{a}	54.84^{a}	3.67^{a}
	LSD	14.68	4.98	0.46	2.77	0.16	2.72	0.39
	CV %	4.93	6.22	5.10	6.34	6.99	5.53	11.72
Farmer	2016/2017	356^{b}	82.7^{b}	11.17^{a}	50^{a}	2.29^{a}	47.36^{a}	2.69^{a}
	2017/2018	388^{a}	89.2^{a}	11.38^{a}	48^{a}	2.39^{a}	50.44^{a}	2.82^{a}
	LSD	27.19	4.65	0.52	5.01	0.22	3.98	0.21
	CV %	7.78	5.76	4.91	10.90	9.91	8.83	8.16
Factor - Cultivar								
Gaya 1	2016-2018	338^{bc}	74.5^{d}	10.22^{bc}	55.7^{c}	2.81^{b}	49.71^{ab}	3.07^{b}
Nikibo	2016-2018	322^{bc}	87.8^{a}	10.1^{c}	63.3^{b}	3.16^{a}	49.36^{ab}	3.22^{b}
Tzarevetz	2016-2018	360^{bc}	78.1^{c}	10.56^{b}	75.8^{a}	3.32^{a}	43.65^{c}	3.05^{b}
Ginra	2016-2018	479^{a}	82.2^{b}	9.87^{cd}	52^{cd}	2.8^{b}	52.43^{a}	3.31^{ab}
Sadovo 1	2016-2018	314^{c}	85.05^{ab}	9.58^{d}	46.6^{e}	2.46^{c}	52.26^{a}	3.51^{a}
Farmer	2016-2018	372^{b}	85.95^{a}	11.28^{a}	49de	2.34^{c}	48.9^{b}	2.76^{c}
	LSD	50.95	3.13	0.40	3.76	0.26	3.14	0.29
	CV %	22.60	6.08	6.33	10.55	14.59	10.15	14.50
Factor - Year								
Year	2016/2017	407^{a}	80.3^{b}	10.45^{a}	56.2^{a}	2.66^{b}	47.05^{b}	2.97^{b}
	2017/2018	321^{b}	84.2^{a}	10.08^{b}	57.9^{a}	2.97^{a}	51.72^{a}	3.33^{a}
	LSD	31.58	2.36	0.30	4.20	0.19	1.89	0.17
	CV %	23.98	8.12	7.98	20.35	18.28	10.59	14.92

Traits N^{a}=N^{a} > N^{ab}>N^{b} >N^{c}>N^{cd}>N^{d} Differences between variants is not significant when alphabet letters are same

(Kirchev, 2019). In terms of the number of kernels in the spike, the most grained cultivar is Tzarevetz (76 grains), with the minimum number being Sadovo 1 (47). The variation in the number of kernels per spike is on average (10.55%), but is close to the upper limit of the low variation. In introduced wheat cultivars there is a low variation of the number kernels of spike and thousand grains weight (Desheva et al., 2015).

The weight grain of spike is maximal for the cultivars Tzarevetz (3.32 g) and Nikibo (3.16 g), which went into one group "A". It is minimal in the cultivar Farmer (2.34 g) and the cultivar Sadovo 1 (2.46 g), for the whole period of the study, went into one group "C". The variation of the trait weight grain of spike is on average (14.59%). Cultivar Sadovo 1 (52.26 g) and cultivar Ginra (52.43 g) have the highest thousand grains weight. The Tzarevetz cultivar has the smallest weight of thousand grains (43.65 g). The cultivar Gaya 1 and Nikibo went into one group "AB" with thousand grains weight (49.71 g) and (49.36 g), respectively. The Farmer cultivar went into group "B" for a weight of thousand grains (48.90 g). The variation of the thousand grain weight per year is between the upper limit of the low variation and the lower limit of the average variation with count of 10.15%. The largest variation is in the number of spikes of m² and the weight of grain from the plot, the lowest variation is in the thousand grains weight, (Lovnyaeva, 2007).

The lower variation of the trait thousand grains weight in the tested wheat cultivars for the whole period of the study, confirms the known about trait thousand grains weight it is stable. But the unproven differences between some of the wheat cultivars require to be combined with other morphological traits for their identification as cultivars about the requirement of distinction.

The kernel density as a trait showed cultivar Sadovo 1 has the highest density (3.51). The cultivar Farmer has the lowest density (2.76). The cultivars Gaya 1 (3.07), Tzarevetz (3.05) and Nikibo (3.22) went into one group "B". The cultivar Ginra is in the intermediate group "AB" of trait kernel density for the whole period of the study. The variation of the kernel density trough all studied cultivars is middle (14.50%).

The plants of the studied cultivars of common winter wheat are the most different of traits height of plant and length of the spike according to the average data for the entire period of the study, and are characterized by low variation. The cultivars have been shown proved difference of the number of kernels in the spike, but the variation is larger.

3. Factor - year of study

According to Andonov (2013), the correlation of the number of kernels per spike with the number of productive tillers per plant is with middle strength, but negative. By years, there is a trend of decreasing the number of productive tillers/m² from the first to (407) the second year (321), statistically proven, (Table 1). In the present study, the correlation (Table 2) of the number of productive tillers/m² with the number of kernels per spike is unproven (r=-0.128 $^{n.s.}$), but is also negative, confirming the study of Andonov (2012). The height of the plants (80-84 cm) has a reverse trend, increasing from the first to the second year.

The length of the spike decreases from the first (10.45 cm) to the second year (10.08 cm), (Table 1). The spikes are shorter in the second year of the study because the temperatures during anthesis are high. The plants are taller due to the smaller number of productive tillers in the second year, this compensates for the effect of higher temperatures in May of the second year. The higher light intensity and lower temperatures during anthesis are favorable for increasing the length of the plants and the length of the spike, as well as for the formation of more grains in the spike. This is associated with the duration of apical elongation, morphological development of the spike (Friend, 2011).

The length of the spike is strongly negatively correlated with the weight of thousand grain (r=-0.864 **). The kernel density has an increasing trend from the first (2.97) to the second year (3.33), (Table 1). A strong negative is the correlation of the spike length with the kernel density (r=-0.974 **), (Table 2). As the grain weight and the length of the spike increase, the kernel density may decrease. The possible reason is competition between spikelets in a state of stress (Leilah & Al Khateeb, 2005; Beheshtizadeh et al., 2013).

Thousand grains weight has an upward trend from the first (47.05 g) to the second (51.97 g) year. The correlation between the thousand grains weight and the kernel density is middle positive, but it is not statistically proven (r=+0.546), (Table 2). The number of kernels in a spike during the two grow-

ing years went into one statistical group, although the cultivars differ by years. There is a tendency of low increase in the number of kernels from 56.2 to 57.9, which is not statistically proven. The reason is probably the large variation (20.35%).

The weight of grain per spike has an increasing trend from 2.66 to 2.97 g, statistically proven, (Table 1). With the correlation analysis of the cultivars it is established that the number of kernels of a spike is in a strong positive correlation with the weight of the grains of a spike (r =+0.929 **). The correlation of the number of kernels of a spike with thousand grains weight is strongly negative (r=-0.864 **), (Table 2). The correlation between the weight of grains of a spike and the thousand grain weight (r=-0.619) is also strongly negative, but not statistically proven. With the low variation are the length of the spike and the height of the plants for the study period in total for the studied cultivars. An additive gene model has been observed in the expression of the nature of plant height in wheat (Tripathi et al., 2011).

The influence of the year in the studied cultivars of common winter wheat is the largest at the thousand grain weight (34.90%), and the smallest proven influence is observed at the spike length 6.97% (Table 3). The greatest influence of the genotype is characterized by the traits number kernels of spike (84.42%) and plant height (71.71%). Spike length (59.16%), weight grain of spike (59.06%) and thousand grain weight (54.12%) has similar values of genotype influence. The influence of the genotype is the weakest in the traits kernel density (29.03%) and number of productive tillers per unit area (34.93%). The total influence of the year with the genotype is greatest in the kernel density (49.02%) and the number of productive tillers / m² (43.87%). The least proven total influence of the year and genotype is found in the number of kernels per spike (13.24%). The length of the spike (26.86%) and the weight of the grains of the spike (26.36%) have similar overall influence of the year and genotype (Table 3).

The genotypes in the dendrogram, generated on the basis of morphological traits, are arranged in it

Table 2. Correlation analysis of the traits for studded cultivars

Traits	NPT/m²	Ph (cm)	SL (cm)	NGS	WGS (g)	TGW (g)	KD
NPT/m²	1	-0.083	0.022	-0.128	-0.028	0.228	-0.048
Ph (cm)		1	0.001	-0.329	-0.294	0.334	0.147
SL (cm)			1	0.174	-0.112	-0.567	-0.974**
NKS				1	0.929**	-0.864*	-0.193
WGS (g)					1	-0.619	0.053
TGW (g)						1	0.546
KD							1

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Legend: NPT/m²-Number of productive tillers/m², Ph-plant height, SL spike length, NKS-number of kernels per spike, WGS-weight of grains per spike, TGW- thousand grains weight, KD- kernel density

Table 3. Analysis of variance and interaction of the factors of the traits

Trait	Year		Genotype		Year x Genotype		Error
	MS	η %	MS	η %	MS	η %	η %
NPT/m²	44204.167***	21.03	14687.9***	34.93	18445.767***	43.87	0.18
Ph (cm)	91.26***	12.47	104.944***	71.71	12.44	8.50	7.31
SL (cm)	0.785**	6.97	1.333***	59.16	0.605***	26.86	7.01
NKS	15.042	0.54	472.242***	84.42	74.042***	13.24	1.81
WGS (g)	0.592***	11.88	0.589***	59.06	0.263***	26.36	2.71
TGW (g)	130.9***	34.90	40.603***	54.12	3.556	4.74	6.24
KD	0.81***	17.99	0.261***	29.03	0.441***	49.02	3.95

Legend: NPT/m²-Number of productive tillers/m², Ph-plant height, SL spike length, NKS-number of kernels per spike, WGS-weight of grains per spike, TGW- thousand grains weight, KD- kernel density

according to the values of their arithmetic means. Genotypes that are genetically very distant are at the top or bottom of a greater number of phenotypic traits (Vieira et al., 2007). The created dendrogram using Ward Linkage showing rescaled distance includes one large cluster and Ginra cultivar, as a single representative of the second cluster. They are at a great linkage distance. The first cluster is divided into two smaller ones. In the first larger cluster are located the cultivars Nikibo, Sadovo 1 and Gaya 1. In the second smaller cluster are the cultivars Tzarevetz and Farmer, which are located in one furket. The first smaller cluster shows similarity in genotypes, most likely due to the parental form of the Bezostaya 1 cultivar, present in most of the pedigrees. Cultivar Sadovo 1 is a parental component of cultivar Gaya 1 (Boyadjieva, 2007; Rachovska et al., 2012). The cultivar Bezostaya 1 is also present in the pedigree of cultivar Farmer and the cultivar Tzarevetz. But cultivar Tzarevetz is a mutant form of the cultivar Pobeda, representing a complex interspecific cross (Rachovska et al., 2012), (Figure 1). The cultivar Ginra is the most remote in the present study. Cultivar Gaya 1 and cultivar Pobeda are located separately in two large clusters in a study by Andonov (2012), confirming the results for the cultivar Farmer. Cultivar Sadovo 1 and Farmer are in two separate clusters at a similar Euclidean distance, as found in the study of Dimitrov (2017).

CONCLUSION

According to the study by traits the length of the spike and the height of the plants studied common winter wheat cultivars falls into different groups; this makes it possible for their distinguish-ability. With the biggest effect of the genotype was characterized both traits number of kernels per spike and the height of the plants. The traits: height of plants, length of the spike and weight of thousand grains was with lowest variation by cultivars and by years. Those traits were with a significant to medium influence of the genotype, and were suitable for morphological markers. Morphological markers have to be used together, because wasn't observed proved differences of trait thousand grains weight between some of the studied cultivars. According to the dendrogram cultivar, Ginra is the most distant from cultivar Nikibo.

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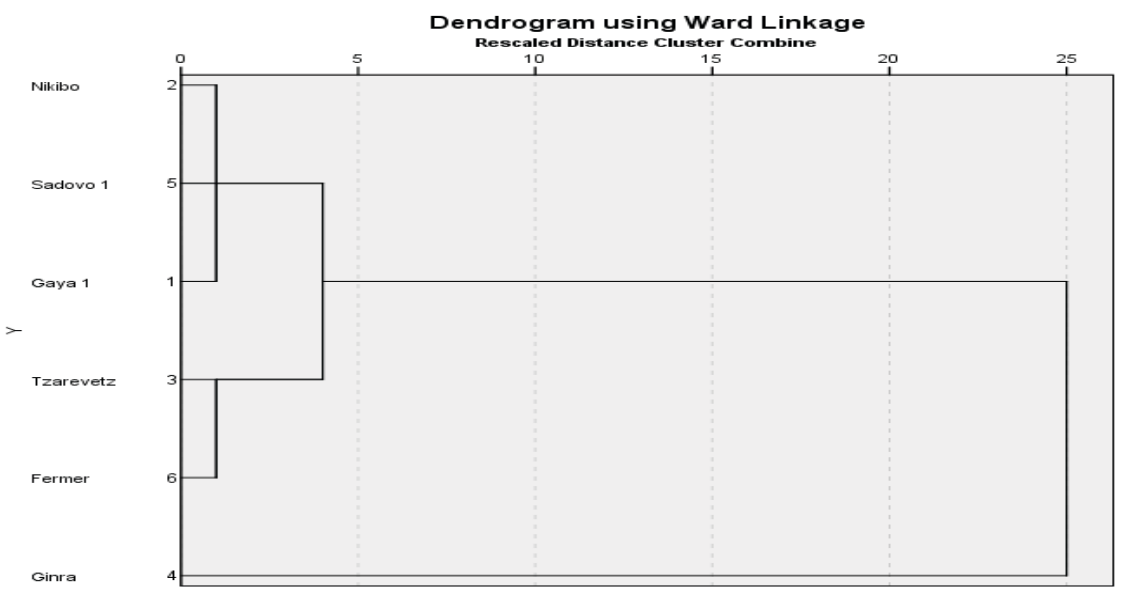

Figure 1. Cluster analysis of six common winter wheat cultivars

Legend: 1. Gaya 1; 2. Nikibo; 3. Tzarevetz; 4. Ginra; 5. Sadovo 1; 6. Farmer

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