AgroLife Scientific Journal - Volume 10, Number 2, 2021
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

CORRELATION OF EFFECTS OF THE GENERAL COMBINATION ABILITY AND THE SIGN OF THE DURATION OF THE SPRING-HILLING PERIOD IN SPRING BARLEY VARIETIES

Volodymyr VASCHENKO[1], Oleksandra SHEVCHENKO[1], Aleksandr VINYUKOV[2], Olga BONDAREVA[2]

[1]Dniprovsky State Agrarian and Economic University, 25 st. S. Yefremov, Dnipro, 49600, Ukraine
[2]Donetsk State Agricultural Science Station of the National Academy of Agrarian Sciences of Ukraine, 1 st. Zashchitnikov Ukrainy, Pokrovsk, 85307, Donetsk region, Ukraine

Corresponding author emails: dnepr182135@ukr.net; olbraun58gm17@gmail.com

Abstract

Determination of the combining ability of varieties and F1 of spring barley is a necessary element in breeding for productivity. The results of the analysis of the general combining ability (GCA) and specific combining ability (SCA) make it possible to organize work on a specific studied feature, to select components for obtaining new hybrid combinations. The method of diallelic crosses was used in the work. The effects of GCA and SCA of spring barley were revealed on the feature of "duration of the germination-heading period". Between the effects of GCA and the estimates of the feature "duration of the seedling-heading period" in varieties there is a high correlation, therefore the value of the feature is an analogous feature of the breeding value, as well as the GCA effect. The stability of GCA effects over the years does not differ from the stability of the germination-heading period, which indicates the same efficiency of selection for any of these features. In the context of climate change towards warming, the determination of the combining ability is an additional tool for predicting selections for this feature.

Key words*: combining ability, correlation, feature, spring barley, variety.*

INTRODUCTION

The use of the effects of general combining ability (GCA) as a criterion for selecting initial varieties for hybridization is based on the assumption that they more fully, in comparison with direct estimates of traits, reflect the properties of a particular variety in various combinations of crosses (Kompanets et al., 2016; Turbin et al., 1966; Litun, 1992; Kilchevsky, 1997).

In spring barley, correlations of various quantitative traits have been established according to their modular structure: general tillering - productive tillering - ear length; productive bushiness - the number of grains per plant - the number of grains in an ear; the number of grains per plant - the mass of grain per ear - the height of the plant; grain weight per ear - grain weight per plant - 1000 grain weight.

Analyzing long-term weather conditions, a feature of which, especially in the last 11 years, are dry-dry wind phenomena, uneven distribution of precipitation throughout the year and the growing season, it was possible to identify a number of patterns and correlations that allow more targeted selection.

Under conditions of insufficient and uneven moisture, the most suitable under conditions of a changing climate are mid-ripening varieties (75-78 days), with an average or increased productive tillering (2.0-2.8 pcs.), With an increased number of ears per 1 m^2 (550-600 pcs.), with medium-sized or above-average grain (1000 grain weight 48-52 g) and suffering from air drought during the flowering period (with a minimum number of empty flowers in the ear), with resistance to powdery mildew, helminthosporium, dusty, hard smut.

The response of varieties to day length and air temperature by accelerating or slowing the beginning of heading affects yield. In years with early spring, earing occurs on May 25-27, with long-term optimal weather, earing on May 30 - June 1, and such varieties bush better.

Intensive varieties, highly responsive to the length of daylight hours, spike on June 2-4, they form high yields only in favorable years.

The possibility of predicting the combining ability of spring barley varieties on the basis of

the severity of the trait, the duration of the "sprout-heading" period has not been experimentally confirmed, therefore, the task of the research was to analyze the correlation between the conditions of this trait and the GCA effects, as well as the stability of the relative severity of the sprout-earing period and the GCA effects (Shevchenko, 2009; Vaschenko, 2013). There is a high correlation between the effects of GCA and a number of traits in cereals.

It has been established that the correlation coefficient between the GCA effects and the grain size of an ear is 0.58-0.99, the grain weight of an ear is 0.75-0.99, and between the number of grains of the main spike, the mass of 1000 grains is within 0.84-0.93 and 0.88-0.97 respectively.

MATERIALS AND METHODS

Fifteen original varieties (Donetskiy 14, Avers, Shchedrik, Stalyy, Rezerv, Repriz, Bravyy, Voyevoda, Avatar, Eney, Komandor, Svyatovit, Galichanin, Statok, Kozatskiy) and 105 of their direct dialle F1 hybrids were tested by the method of randomized blocks in 2019-2020.

Donetskiy 14, originator of the Donetsk State Agricultural Science Station of the NAAS (DSASS NAAS). It is the steppe ecotype, intense, plastic, drought-resistant, resistant to lodging and the most common diseases. Mid-ripening, growing season is 76-86 days, plants are undersized (53-61 cm). The mass of 1000 grains is 52-66 g, the content of crude protein in the grain is 12.0-13.8%. Productivity 4.6 t/ha. Valuable. For growing in the steppe and forest-steppe zones of Ukraine.

Avers, originator of the DSASS NAAS. It is the steppe ecotype, mid-ripening, growing season is 75 to 80 days. Plants have 60-72 cm height. Possesses high resistance to lodging, mechanized harvesting, drought-resistant. The mass of 1000 grains is 48-50 g. The yield is 4.8 t/ha. For growing in the steppe and forest-steppe zones of Ukraine.

Shchedrik, originator of the DSASS NAAS. A variety is the steppe ecotype. It is mid-season, growing season is 70-78 days. Plant height is 75 cm. It is drought-resistant. The mass of 1000 grains is 47-51 g. Productivity is 4.5-5.5 t/ha. For growing in the steppe and forest-steppe zones of Ukraine.

Stalyy, originator of the DSASS NAAS. A variety is the steppe ecotype. It is mid-season, growing season is 70-75 days. Plant height is 75 cm. It is resistant to lodging, to drought. The mass of 1000 grains is 48-50 g. Productivity is 5.3 t/ha. For growing in the steppe and forest-steppe zones of Ukraine.

Reserv, originator of the DSASS NAAS. It is a variety of the steppe ecotype. It is mid-season, growing season is 76 78 days. Plants are 65-75 cm high. The mass of 1000 grains is 48-50 g. Productivity is 5.5 t/ha. For growing in the steppe and forest-steppe zones of Ukraine.

Repris, originator of the DSASS NAAS. The growing season is 82 - 88 days. Plant height - 62.1 - 78.1 cm. Protein content - 11.9 - 13.5%. The mass of 1000 grains is 51.2 g. Productivity is 5.6 t/ha. It has resistant to lodging, shedding, drought, powdery mildew, leaf rust, helminthosporium. For growing in the steppe and forest-steppe zones of Ukraine.

Bravyy, originator of the DSASS NAAS. The growing season is 79 - 84 days. Plant height is 65.8 - 71.5cm. Protein content is 13.6-13.8%. Grain evenness - 93.2-95.6%. It has resistance to lodging, shedding, drought, powdery mildew, brown rust, helminthosporium. For growing in the steppe and forest-steppe zones of Ukraine.

Voyevoda, originator of the Institute of Breeding and Genetics - National Center for Seed Production and Variety Research UAAS (IBG-NCSPVR UAAS); Selena CJSC. A variety of the steppe ecotype, grain, brewing. It is mid-ripening, growing season is 75-80 days. It has resistant to drought, lodging, disease. Weight of 1000 grains is 48-52 g. Protein content under drought conditions is 11.8-12.0%. Grain evenness - 97%. Recommended growing area: Forest-steppe, Polesie.

Avatar, originator of the IBG-NCSPVR UAAS; Selena CJSC. The growing season is 75-80 days. Drought-resistant, lodging resistant, complex resistance to major diseases. Grain evenness - 95%. Weight of 1000 grains - 50-55 g. Productivity 5.52 t/ha.

Eney, originator of the IBG-NCSPVR UAAS. Vegetation period is 76-86 days. Drought-resistant, lodging resistance, high disease resistance. Masa 1000 grains - 50-51 g. Productivity 5.87 t/ha. It is a valuable. Recommended for all zones of Ukraine.

Komandor, originator of the IBG-NCSPVR UAAS. Recommended for forest-steppe and Polesye, brewing. It is mid-ripening, growing season is 76-79 days. It has drought-resistant, resistant to lodging, powdery mildew, helminthosporiosis, dwarf rust, dusty, black and stone smut. The mass of 1000 grains is 48-50 g. Productivity is 5.51 t/ha.

Svyatovit, originator of the IBG-NCSPVR UAAS. It is mid-season, growing season is 74-77 days. Plant height is 77 cm. It has drought-resistant, resistant to lodging and grain shedding. It has high resistance to powdery mildew, helminthosporiosis, not affected by smut diseases. The mass of 1000 grains is 48 - 54 g. Productivity is 5.61 t/ha. Recommended for all zones of Ukraine, brewing. The protein content is 11.4%. Grain evenness - 94 - 96%.

Galichanin, originator of the IBG-NCSPVR UAAS. It is six-rowed, short-stemmed. Plant height is 60 - 65 cm, mid-season, vegetation period is 75 - 78 days. It has resistant to lodging and shedding of grain, resistant to diseases. Weight of 1000 grains is 45-50 g. Productivity is 5.5 t/ha. Recommended for Steppe and Forest-steppe, valuable.

Statok, originator of the Kirovograd Institute of Agroindustrial Production of the UAAS. Steppe ecotype. Semi-intensive, mid-season, highly plastic. Plant height is 65-70 cm. The growing season is 82-85 days. Highly resistant to leaf diseases, lodging and drought. The mass of 1000 grains is 43-50 g. Recommended distribution zones are Steppe, Forest-steppe, Polesie.

Kozatskiy, originator Nosovskaya selection experimental station of the Chernigov IAP of the NAAS. Recommended growing area: Polesie. It is mid-season, vegetation period ши 87-98 days. Plants have height of 63-70 cm. Resistance to lodging and shedding, to certain types of diseases is above average. The mass of 1000 grains is 41.3-46.8 g.

The research was carried out at the experimental plots of the Donetsk State Agricultural Science Station of the National academy of agrarian sciences of Ukraine. The aim of the work is to analyze the correlation of combinatorial abilities for the studied feature in order to obtain new hybrid combinations.

For each variant, 100 grains were sown. Sowing was carried out to a depth of 5-6 cm using an SKS 6-10 cassette seeder. During the growing season, phenological observations were carried out: the dates of sowing, germination, tillering, earing, and wax ripeness were noted. In the phase of full sprouting, earing, wax ripeness, the general field assessment of varieties was carried out on a nine-point scale. The following indicators were taken into account: plant development, uniformity in morphology and stem, plant density, resistance to lodging and disease. Harvesting was carried out at the stage of full ripeness. After harvesting, a structural analysis was carried out according to the indicators: productive tillering, number of grains in an ear, weight of 1000 grains, weight of grain of an ear and a plant.

Based on the data obtained, the duration of the germination-heading period was calculated for each variant, then the results were entered into the diallel table using the second Griffing method using computer Exel, Statistica 6.0 and the software package for processing selection and genetic experiments developed by the Institute of Plant Industry named V.Ya. Yuriev, NAAS of Ukraine.

In the research, we used the Methodological recommendations (Wolf & Litun, 1980), as well as the methods of biological statistics (Rokitsky, 1973; Gardner & Eberhart, 1966; Savchenko, 1973).

RESULTS AND DISCUSSIONS

The hydrothermal conditions of the study period were contrasting. Monthly distribution of precipitation was uneven. In 2019, spring temperatures were above the annual average. The amount of precipitation for the month was 44 mm or 116% of the monthly norm. In May, the average air temperature was 17-18°C, the amount of precipitation was 62 mm (132% of the monthly norm). The average air temperature in June was on 3-5° higher than the norm and was determined to be 23.5-24.5°C. The amount of precipitation for the month was 33 mm or 53% of the monthly norm. Deficit of precipitation, low relative humidity, insufficient moisture reserves in April 2020 negatively affected the plants of spring barley. In May, abnormally humid cool weather was observed, in June such phenomena as drought, heavy rains, squall winds (Figure 1).

An important stage in the selection process in the creation of adaptive varieties is the assessment of the initial material by combining ability in regard to the growing season and its part of the time of emergence-heading.

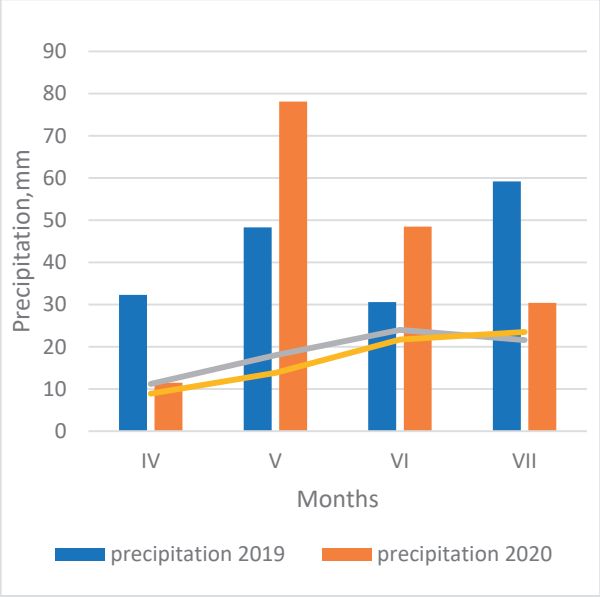

Figure 1. Climatic conditions of the growing season of spring barley

Combination value is a genetically determined property. It has been experimentally proven that varieties with good combining ability give more productive seed offspring. Therefore, try to find any easily fixed features that sufficiently correlate with the combinational ability and their owners. The main attention is paid to the productivity of varieties and hybrids obtained from hybridization. The known methods for predicting this biological property are not informative enough, therefore, there remains one reliable way to assess the combinational ability - crossing with subsequent testing of hybrid offspring.

The growing season determines the distribution area of varieties, their potential and actual yield. The development cycle of spring barley is divided into two periods: sprouting-earing and earing-maturation (vegetative and reproductive phases). It has been established that there is a high correlation between the duration of the growing season and the duration of the sprout-heading phase; therefore, the study of the sprout-heading period is of particular practical interest.

A review of experimental data shows that the growing season in F1 hybrids is controlled by the polygenic genetic system. Genetic analysis of the duration of the germination-heading period revealed the advantage of the additive-dominant gene system in determining the indicator, i.e. intralocus dominance and additivity between loci are manifested. Partial, incomplete, and complete dominance and overdominance were noted within the loci. This phenomenon is explained by the set of studied varieties in the experiment, and by the meteorological factors of the growing season.

Analysis of middle varieties and hybrids of the first generation shows their approximate equality. The difference between varieties and hybrids in terms of earing time and their variability depending on hydrothermal conditions in the years of research demonstrates the share of the influence of factors on the indicator (Table 1).

Table 1. The percentage of the influence of factors on the variability of the duration of the sprouting-earing period

Factor	mS	%
Conditions of the year (A)	3889.52*	99.76
Genotype (B)	5.12*	0.15
Interaction (AxB)	2.38*	0.07
Error	0.52	0.02
$P \leq 0,05$		

Analysis of variance of the initial data showed that there are significant differences between genotypes (varieties, F1 hybrids), this made it possible to calculate the mean squares of the GCA, specific combining ability (SCA) and compare them with the mean square of the random variation of the feature (Table 2).

Table 2. Combining ability of the germination-heading period

Variant	year	df	mS
GCA	2019	14	44.92*
	2020	14	55.21*
SCA	2019	105	1.01*
	2020	105	1.03*
Random deviations	2019	357	0.20
	2020	357	0.17

* at P = 0.01

The results presented in Table 2 indicate the importance of GCA and SCA in the analysis of F1 hybrids. The significant advantage of the mean square of the GCS in comparison with the SCA indicates the predominance of the additive effects of genes in the determination of feature. In more favorable conditions of 2020,

the expression of the additive effects of genes increases slightly.

The influence and variance of SCA is significant, which indicates the effects of allelic and non-allelic interactions of genes. The value of a feature in hybrids is determined mainly by the additive action of genes, therefore, the selection of the best varieties can be carried out according to the effects of GCA (Table 3).

Table 3. GCA effects on the basis of "duration of the germination-heading period" (F1 years)

No.	Variety	Effect of GCA		Average for two years
		2019	2020	
1	Donetskiy 14	-1.07	-2.03	-1.55
2	Avers	-3.64	3.24	-3.44
3	Shchedrik	-0.19	-0.61	-0.40
4	Stalyy	-1.92	-2.06	-1.99
5	Rezerv	-1.41	-0.54	-0,97
6	Repriz	-0.66	-0.32	-0,74
7	Bravyy	+0.26	-0.32	-0.05
8	Voyevoda	+1.16	+1.36	+1.26
9	Avatar	+1.01	+1.85	+1.43
10	Eney	-0.10	-0.75	-0.43
11	Komandor	+0.10	-0.42	-0.16
12	Svyatovit	+1.00	+1.05	+1.03
13	Galichanin	+3.38	+3.78	+3.62
14	Statok	+0.60	+0.92	+0.47
15	Kozatskiy	+1.47	+1.74	+1.61
	$LSD_{0,5}$	0.40	0.35	

The smallest GCA effects have the varieties Shchedrik, Rezerv, Repriz, Eney. The same cultivars are early streaked among the studied set, i.e. there is a clear correspondence between the GCA effects and the estimates of the feature levels in the initial varieties: the correlation between these indicators is highly consistent over the years of research (Tables 4, 5). The correlation coefficient between the effects of ACS and the values of the trait "duration of the germination - heading period" is 0.94 and 0.95. Thus, the research results of the relationship between the effects of GCA and the values of the feature "duration of the period" sprouting - heading "are in full agreement with the data for other features. Therefore, it can be argued about the relationship of these indicators as a general pattern, the reasons for which lie in the similarity of the genetic nature of GCA effects and environmental effects. From the postulates of genetics of quantitative features, the effects of ACS in the additive-dominant model are equal to the sum of the additive effects of genes for the two-locus model (Kilchevsky, 1997). In the presence of a non-allelic interaction, the effects of GCA include additive epistasis.

Table 4. Average values of the feature "duration of the germination-heading period" in the initial varieties

No.	Variety	Feature value, days		Average
		2019	2020	
1	Donetskiy 14	41.7	40.3	41.0
2	Avers	41.5	40.6	41.1
3	Shchedrik	40.2	41.0	40.6
4	Stalyy	42.7	42.3	42.5
5	Rezerv	43.2	42.0	42.6
6	Repriz	40.3	41.1	40.7
7	Bravyy	40.7	31.8	40.3
8	Voyevoda	43.1	42.2	42.7
9	Avatar	45.0	44.1	44.6
10	Eney	41.7	40.8	41.3
11	Komandor	44.2	43.7	43.9
12	Svyatovit	45.2	44.0	44.6
13	Galichanin	48.2	46.1	47.2
14	Statok	46.1	45.9	46.0
15	Kozatskiy	50.1	48.6	49.4
	$LSD_{0,5}$	1.8	1.6	

Table 5. Correlation coefficients of GCA effects with the severity of the feature "duration of the germination - heading period“ (F1)

Generation	Correlation coefficient			
	2019	2020	average	
F_1	0.94	0.95	0.95	
F_1	0.91	0.96	0.94	P = 0.01

It is known that the effect of a cultivar, defined (Gardner, 1966) as the difference between the values of a feature in an individual cultivar and the average for all studied cultivars, is also determined by additive and additive epistatic genes (Wolf, 1980). Therefore, it follows that, in the ideal case, we should observe a functional relationship between the severity of features in varieties and the effects of GCA.

In this regard, it can be assumed that the effects will have a higher stability over the years of research in comparison with direct estimates of the corresponding features in varieties.

Therefore, we calculated the correlation coefficients between the estimates of the GCA effects obtained in 2019-2020 and compared them with the correlation of the values of the "germination-heading period duration" feature, and found that the stability of the GCA effects did not differ from the stability of the feature in the original varieties. Consequently, the reliability of the selection of varieties based on the effects of GCA has no advantage over

direct selection in terms of the duration of the germination-heading period.

CONCLUSIONS

There is a high correlation between the effects of GCA and the estimates of the feature "duration of the germination-heading period" in varieties, therefore the value of the trait is an analogous indicator of the breeding value, like the effect of GCA.

The stability of GCA effects over the years does not differ from the stability of the germination-heading period, which indicates the same efficiency of selection for any of these indicators.

In conditions of climate change towards warming, the determination of the combining ability is an additional tool for predicting selections for this feature.

REFERENCES

Gardner, C.O., Eberhart, S.A. (1966). Analysis and interpretation of the variety cross diallel and related populations. *Biometrics*, 22, 439-452.

Kilchevsky, A.V., Khotyleva, L.V. (1997). *Ecological plant selection.* Minsk.

Kompanets, E.V., Kozachenko, M.R., Vasko, N.I., Naumov, A.G., Solonechnyy, P.N., Svyatchenko, S.I. (2016). Breeding value of spring barley varieties and their parental forms. *Bulletin of the Belarusian State Agricultural Academy*, 3, 55-60.

Litun, P.P., Proskurnin, N.V. (1992). *Genetics of quantitative features. Genetic crosses and genetic analysis.* Kiev. UMKVO.

Rokitsky, P.F. (1973). *Biological statistics*. Minsk.

Savchenko, V.K. (1973). *A method for assessing the combining ability of genetically different sets of parental forms. Methods of genetic selection and genetic experiments.* Minsk: Science and Technology.

Shevchenko, O.O. (2009). An analysis of the correlation between the clearest signs of fervent barley in the young minds of viroshuvannya. *Selection and production,* 17, 245-251.

Turbin, N.V., Tarutina, L.V., Khotyleva, L.V. (1966). Comparative evaluation of methods for analyzing combining ability in plants. *Genetics*, 8.

Vaschenko, V.V., Shevchenko, O.O. (2013). The adaptability and stability of barley ardent for the indicators of productivity. *Visnik DDAU*, 2, 22-25.

Wolf, V.G., Litun, P.P. (1980). *Methodical recommendations on the use of mathematical methods for the analysis of experimental data on the study of combining ability.* Kharkov.