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INHERITANCE OF QUANTITATIVE TRAITS AND BIOMETRIC INDEXES OF KNEJA 560 HYBRID. I. EAR LENGTH, NUMBER OF ROWS PER EAR, GRAIN ROW NUMBER

Valentina Valkova*, Natalya Petrovska

Maize Research Institute – Kneja, Bulgaria
***corresponding author's e-mail: valkova_valentina@mail.bg**

Abstract

The study was conducted during 2017-2019 in the experimental field of the Maize Research Institute - Knezha, by the block method, two plant densities - optimal (5500 pl/da) and increased (7000 pl/da), according to the agricultural techniques typical for the region. The inheritance of the quantitative traits and biometric indexes related to the productivity of the newly created, high-yielding medium-late hybrid Kneja 560 and its affiliated generations have been studied.

The aim of the study is to analyze and evaluate the predominant genetic actions and interactions in the inheritance of quantitative traits in maize, their relationship with the manifestations of heterosis and gene effects.

High manifestations of heterosis were found for the traits ear length and grain row number. The values vary according to the different environmental conditions, without changing the direction of this manifestation. In the inheritance of these traits, the largest share is overdominance.

The dominant gene effects have the largest relative share in the genetic control of the ear length.

The results of this study complement to the evaluation of this newly hybrid from the collection of Maize Research Institute - Knezha.

After analysis of the obtained results, specific recommendations were made for the inclusion of these materials in effective breeding programs.

Keywords: maize, affiliated generation, heterosis, levels of dominance, gene effects, correlation relations

INTRODUCTION

In Republic of Bulgaria, the agricultural business with maize grain operates and develops in dynamic environment in compliance with the EU requirements, the foreign companies' invasion on the grain market and the climate conditions' changes during the plant vegetation. Agricultural practice show that maize hybrids reach their full potential in the regions and under the continuations where they have been created and for which they have been zones (Suprunov, 2009; Petrovska et al., 2017 (b); Song et al., 2019). Planting in regions with different climate conditions brings a risk for their productive potential and might compromise the yield. This puts in front of the breeders the tough task for development of a new generation higher yield hybrids that are sustainable to abiotic and biotic stress; that would this play the characteristics of effective water consumption, better grain quality, fast moisture release at harvest, shorter vegetation period for faster clearance of the areas, high harvest index and better adaptability to the climate conditions changes.

The inclusion of surveyed source material possessing economically important traits is obligatory for the greater effectiveness of breeding process of new hybrids development and for

the proper breeding methods and schemes. The question how these traits are inherited should be clarified, as well as how the gene effects participate in the formation and expression of these traits (Yordanov, 2013; Pencheva, 2017; Petrovska et all. 2017 (a); Vulchinkova et all., 2018; Ilchovska, 2019).

Kneja 560 is a new, high-yield hybrid from the medium late maturity group. It is approved and enlisted in the A List of the country's Official Varietal List by order No RD 12-4/13th of June, 2017 of Ministry of Agriculture and Food /MAF/. It was awarded with Gold Medal for good presentation at Tenth National Exposition "Inventions, Transfer, Innovations –ITI, 2017" (Valkova, et al., 2018; Valkova et al., 2020).

The survey goal is to estimate the gene actions and interactions in inherited the quantitative traits are inherited; their connections with heterosis expression and the gene effects in the newly developed and perspective hybrid Kneja 560. This will contribute to the selection evaluation of the hybrid and will add additional knowledge of the heterosis nature, as main method in maize breeding.

MATERIALS AND METHODS

The experimental work was done in the field of Maize Research Institute/MRI/ - Knezha during the period 2017-2019. During the survey's first year in the MRI-Knezha selection field and under isolator were obtained and reproduced the maternal (P1) and paternal (P2) forms of hybrid Kneja 560. Its first generation – the single cross hybrid (F1), was produced. During the next year were produced the second hybrid generation (F2), the backcross to maternal form (BCP1) and the backcross to paternal component (BCP2). During 2019, all filial generations were tested in randomized field trials, after the block method, with two repetitions, on 10 m2 trial plot and agricultural equipment normally applied in the region, and under conditions without irrigation. The trials were set up with two seeding densities – 5500 pl/da and 7000 pl/da.

Twenty plants had biometrical measurements of their stem and cob for P1, P2 and F1, while for F2, BCP1 and BCP2 were measured 60 plants from each repetition. The biometric indexes: overall height of plants, height of the ear location, number of leafs and ear leaf area are analyzed. The measurements were made after reaching the maximum height of the plants, ie. After flowering of the panicle phase. When harvesting the experiments from each replication, the mentioned number of ears was taken to determine the indicators (ear length, number of rows per ear, grain row number, grain weight of the ear, length of the grain and ear grain present) in laboratory conditions.

Genetic analysis was performed on the data from these indices in order for the real and hypothetic heterosis in F1 and the inbred depression in F2 to be determined (Omarov, 1975). Domination rates in F1 were determined after the method of Romero and Frey (1973). The relative share of gene effects in traits' inheritance was studied (Gamble, 1962a, b), as well as the inheritance in general sense (H^2) - after the method of Genchev et al., (1975 г.). According to the classification, inheritance in broad sense has three levels: high – coefficient values are between 30-60%, medium – 10-30% and low – 5-10%.

RESULTS AND DISCUSSION

Table 1 shows the average values of the studied indices – ear length, number of rows per ear, grain row number for Kneja 560 hybrid (F_1), its parental components (P_1 and P_2) and the hybrid generations (F_2, BCP_1 and BCP_2). The data present the results from two cultivation densities – optimal (5500 pl/da) and increased (7000 pl/da). Setting the trials under two seeding densities ensures different conditions for the plants' development (water, nutritional, light, air regime) without any changes in the remaining complex of environmental conditions. This allows the density tolerance of particular genotype seeding's to be monitored and, in the meantime, the genetic parameters' changeability to be followed under different complex of cultivation conditions. The data in this table clearly demonstrate that the higher seeding density results in decreased ear length and grain row number in all studied generations. Weaker impact is reported with the heterozygous genotypes. Seeding density has the least impact number of row per ear, where the trait variability is insignificant.

Table 1. Mean values of the traits ear length, number of row per ear, grains row number

Traits	Plant density (pl/da)	Populations					
		P1	P2	F1	F2	BCP1	BCP2
Ear length (cm)	5500	18.33 (±0.95)	20.85 (±1.29)	23.55 (±0.92)	20.58 (±1.92)	19.14 (±1.62)	22.65 (±1.98)
	7000	16.83 (±1.68)	16.63 (±1.79)	22.10 (±1.21)	19.80 (±1.94)	19.50 (±1.69)	21.33 (±2.01)
Number of rows per ear	5500	15.10 (±1.52)	18.20 (±2.50)	18.70 (±1.49)	17.03 (±1.97)	16.40 (±1.46)	18.70 (±1.83)
	7000	14.90 (±1.21)	19.60 (±1.23)	18.80 (±1.51)	17.83 (±2.06)	16.47 (±1.96)	19.37 (±2.19)
Grains row number	5500	35.80 (±4.54)	44.25 (±4.30)	53.95 (±2.09)	45.28 (±4.46)	42.43 (±4.21)	48.05 (±4.25)
	7000	31.25 (±2.99)	34.65 (±4.26)	48.70 (±5.07)	44.08 (±4.30)	43.20 (±4.32)	46.77 (±4.84)

Table 2. Correlation relations between grain yield and elements of productivity of Kneja 560 hybrid.

Traits	Yield (kg/da)	Ear Length (cm)	Number of rows per ear	Row grains number
Grain yield (kg/da)	1			
Ear length (cm)	0.9716	1		
Number of rows per ear	-0.4611	-0.574	1	
Grains row number	0.8732	0.959	-0.747	1

Table 2 shows the correlative relationships between the studied traits and the yield. The correlative analysis allows to establish relationships either between the studied traits or between them and the yield as the most important complex index. Maize Research Institute /MRI/ - Knezha has carried out numerous studies proving the correlative relationships between important parameters for maize, but the achieved results were not always in one direction (Yordanov, 1995; Petrovska et al., 2010; Valkova et al. 2010; Ilchovska, 2012). The accuracy of these estimations depends on the different genotype reaction, the genotypes' number included in the study excerpt, the growing conditions etc. The data of this study demonstrate that the grain yield depends to the highest extend on the ear length (r=0,9716) and on the grain row number (r=0,8732). The relationship between grain row number and the ear length is also strong (r=0,959). These results confirm previous studies (Yordanov, 1999; Ilchovsk., 2012). The relationship between number of row per ear and the yield is in opposite direction and moderate rate (r=-0,461). Before us these results were obtained by Mitev & Hristova (2002), who state that under favorable climate conditions there is no correlation between number of row per ear and the yield.

In this study, the heterosis measurement and estimation was accomplished in compliance with a method suggested by Omarov (1975), which allows it to be analyzed in two directions. The first one is from genetic standpoint, as the trait super-expression in hybrid generation F1 compared to the average value of this trait of both parents (hypothetic); the second one is from selection standpoint (natural), when the hybrid has better expression of the questioned trait compared to the better parent.

Turbin et al. (1974) classify the hybrids as high-heterosis when the genuine heterosis for a certain trait is more than 20% and as low-heterosis when genuine heterosis values are between 10-19.9%. Estimated in compliance with this scale the Kneja 560 hybrid has high heterosis level for the traits – number of rows per ear and ear length (Table 3). When these traits are being inherited, positive super-domination (h1>1) is monitored, and in F_2 – inbred depression. This proves once again that heterozygosity is in the basis of heterosis expression (Genchev, 1973).

Table 3. Heterosis effect. inbreding depression and dominance in F1 and F2 for the traits ear length, number of row per ear, grains row number of hybrid Kneja 560

Traits	Plant density (pl/da)	Heterosis effect in F1 (%)		Inbreding depression in F2 (%)	Degrees of dominance		Heritability in broad sense (H^2)
		Hypothetical	Real		h1	h2	
Ear length (cm)	5.500	20.23	12.95	12.60	3.14	1.58	71.31
	7.000	32.14	31.35	10.41	53.75	61.50	40.52
Number of rows per ear	5.500	12.31	2.75	8.91	1.32	0.49	15.74
	7.000	8.99	-4.08	5.14	0.66	0.50	55.65
Grains row number	5.500	34.79	21.92	16.06	3.30	2.49	39.91
	7.000	47.80	40.55	9.48	9.26	13.10	-6.31

Table 4. Gene effects for inheritance for the traits length of the grain. mass on grains per ear, percent of in the grain in ear of hybrid Kneja 560

Traits	Plant density (p/da)	Genetic background (m)	Additives (a)	Dominances (d)	/Epistasis interactions		
					(aa)	(ad)	(dd)
Ear length (cm)	5.500	20.58	-3.51	5.21	1.25	-2.25	1.44
	7.000	19.80	-1.83	7.82	2.44	-1.93	-6.43
Number of rows per ear	5.500	17.03	-2.30	4.12	2.07	-0.75	-1.57
	7.000	17.83	-2.90	1.88	0.33	-0.55	0.10
Grains row number	5.500	45.28	-5.62	13.76	-0.17	-1.39	7.15
	7.000	44.08	-3.57	19.35	3.60	-1.87	-20.23

The trait number of rows per ear has low positive, genuine heterosis at the optimal plant density and negative heterosis at the increased plant density. This trait heredity is medium in F_2 and also at the higher density in F_1. At the optimal density, this trait heredity in F_1 is a result of overdominance. These results confirm previous conclusions that the trait heredity is under complex genetic control without definite domination of particular gene effects (Ivanov, 1995; Yordanov, 2013; Petrovska et al., 2017 (a)).

Analysis and estimation of the variability relative part as a result of the genetic reasons are made from the heredity coefficient in broad sense (H^2). In this hybrid, the traits ear length and number of rows per ear have high and medium heredity. This means that phenotypic selection for these traits can be done as the phenotypic expression will correspond to the genetic value of the selected genotype. This selection is not recommended for the trait grain row number as the heredity data are not confirmed and depend on the growing conditions. The classification was accomplished in compliance with methods of Genchev (1975).

Table 4 presents the complex analysis of gene effects at the analyzed traits heredity in Kneja 560 hybrid.

The dominant gene effects (d), which have positive values and assist the traits' expression, have the largest relative share in the traits' heredity. The adaptive (a) and epistatic (ad) effects, which have negative values and reduce the traits' expression, have a lower share. The additive x additive (aa) gene correlations contribute for the formation and heredity of ear length and number of rows per ear at both seeding densities, as well as for the row grain number at the increased density. The impact of the dominant x dominant (dd) gene effects is different for the individual traits and growing conditions.

CONCLUSION

Analysis of the obtained results leads to the following conclusions:

- Heredity of ear length trait in the average late hybrid Kneja 560 occurs at high values of heterosis expression in F_1 hybrid generation that is combined with well defined depression in F_2. The dominant gene effects (d) have the largest relative share in the trait heredity.
- Hybrid Kneja 560 is high-heterosis for the row grains number trait. The dominant gene effects (d), which are positive and assist its expression, have the highest share in the traits' heredity. The additive (a) and epistatic (ad) effects, which bear negative values and reduce the trait performance, have a lower share.
- The number of rows per ear trait is with the lowest heterosis expression in the hybrid generation. At optimal seeding density this trait heredity in F_1 is a result of overdominance, while at increased density – the heredity is medium.
- In general, as to Kneja 560 hybrid, the traits ear length and number of rows per ear have high and medium heredity, which is a prerequisite for phenotypic selection for these traits as the phenotypic expression will correspond to the genetic value of the selected genotype. This selection is not recommended for the trait grain row number as the heredity data are not confirmed and depend on the growing conditions.

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