COMBINING ABILITY FOR EAR LENGTH AND ROW NUMBER OF SOME MAIZE HYBRID COMBINATIONS (*Zea mays L.)*

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ABSTRACT

The main object was to evaluate F_1 maize hybrids for ear length and the number of rows. Investigations included ten (10) diallel crossed inbred lines analyzed for General Combining Ability (GCA) and Specific Combining Ability (SCA). The components of genetic variance were calculated using Griffing's formula, method 2, mathematic model I. $X_{ijk}=\mu+gi+gj+s_{ij}+e_{ijk}$. Additive gene effects were more important than non additive since the ratio was 0.45 for ear length (EL) and 2.67 for the number of rows (NR/E), among GCA and SCA. The grand mean μ for EL and NR/E was 20.4 cm/ear and 16.7 rows/ear. Heterozygote combinations L6xL10 (22.33 cm/ear) showed maximum EL, while for NR was L5xL9 (19.2 rows/ear). Hybrid combination L1xL10 showed minimum values EL (15.9 cm/ear) and NR/E (14.3 rows/ear).

Keywords: F_1 generation, combining ability, ear length, number of rows per ear.

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Objektivë kryesore e këtij studimi ishte studimi i disa kombinimeve hibride të misrit për matje biometrike të kallirit; Gjatësi dhe numër të rendeve në kalli(GJK, NRK). Në hulumtime janë përfshirë dhjetë (10) linja inbrede të misrit të cilat janë futur në kryqëzime dialele për Aftësi të përgjithshme kombinuese (APK) dhe të veçantë kombinuese (AVK). Komponentja e variancës gjenetike ishte llogaritur duke shfrytëzuar modelin e Griffing[1] metoda 2, modeli matematk I; $X_{ijk}=\mu+gi+gj+s_{ij}+e_{ijk}$. Duke u bazuar në raportin për APK/AVK për GJK (0.45) dhe NRK (2.67), veprimi i gjeneve aditive ishte më i lartë se sa ato joaditive. Vlera e përgjithëshme eksperimentale për GJK dhe NR/K ishte 20.4cm/kalli, respektivisht 16.7 rende/kalli. Me vlerë maksimale për GJK ishte kombinimi heterozigot L6xL10 (22.33 cm/kalli), kurse për NRK ishte L5xL9 (19.2 rende/kalli). Me vlerë minimale për GJK dhe NRK është realizuar te kombinimi hibrid L1xL10 (15.9 cm/kalli), respektivisht L7xL10 (14.3 rende/kalli).

INTRODUCTION

Maize (Zea *mays L.*) is the world's most widely grown cereal and the primary staple food in many developing countries. The first maize hybrids for farm use were produced in the 1920s, but until the 1940s most farmers still were growing open-pollinated (OP) varieties. In very short season areas, the OPs were flints because of their tolerance to cool, wet spring conditions and requirement for fewer heat units to reach harvestable maturity. But the most maize by far was planted to OPs form a new race of maize, Corn Belt Dent that arose somewhat serendipitously during the early decades of the 1800s, according to the data [2].The use of heterosis in the world started in 1933 when in USA were planted about 1% of the total surfaces, while latter in year 1953 the heterosis of the maize hybrids were expanded up to 96% [12]. The production of hybrid seed requires the development and maintenance of inbred lines and subsequent controlled crosses to produce commercial seed [14]. The improvement of maize traits depends on the knowledge of the type of the gene action involved in its inheritance and also the genetic control of the related traits such as capacity of production [9]. Also the choice of the most efficient breeding program depends on that information [3], and [7]. The concept of general combining ability (GCA) and specific combining ability (SCA) was introduced [12] and its mathematical modelling was presented by Griffing [1] in his classical paper in conjunction with the diallel crosses [5]. Diallel crosses have been widely used in genetic research to investigate the inheritance of important traits among a set of genotypes. Analyses of diallel data is usually conducted according to the methods of Griffing [1] which partition the total variation of diallel data into GCA of the parents and SCA of the crosses [13]. The objective of this study was to evaluate the performance of ten maize inbred lines at agro ecological conditions in Kosovo for ear length and number of rows. These were specifically designed to investigate the combining ability of the parental lines for the purpose of identification of superior parents for use in hybrid development programmes.

Material and methods

Plant material and field design

The experimental material comprised of ten (10) superior medium maturity inbred lines of maize (L1, L2,… L10), originating from the Agriculture University of Tirana (AUT)–Albania (see Tables 2 and 3), were used for crosses in this study. These ten (10) inbreed lines of maize were crossed in a diallel mating design without reciprocal combinations and tested in randomized block (RBDE) with three replications (45 hybrid combination x 3 replications = 135 experimental plots,(EP)). Location was in agro-ecological conditions in Kosovo, in the area near Ferizaj (580 m a.s.l). After the fourth year, ten (10) selected maize inbred lines were crossed using diallel model and the next year these genotypes were placed in EP of hybrid combination (C) and to study GCA and SCA for yield kernel per ear (YK/E) was conducted. The experimental plot was 3 m long and 60 cm apart, with 30 cm plant to plant distance or 55000 plants per ha^{-1}. The experimental plots were 5.4 m^2 per each replication x 3R = 16.20 m^2. In order to determine length and number of rows we measured the average of 10 ears or plants randomly selected from each plot (10 ear per plants x 3R =30 plants or in total 1350 plants).

Statistical analyses

The diallel analysis, as described by Griffing's^1 method 2, mathematic model I fixed model:

$X_{ijk}=\mu+gi+gj+s_{ij}+e_{ijk}$

Where:

X_{ijk} = is the mean of i x j^{th} genotypes,

μ = is the experimental grand mean,

g_i and g_j = is the GCA effects of i-th female parent, effects of j-th male parent,

S_{ij} = is the SCA effects specific to the hybrid

Source	d.f.	S.S.	
GCA	p-1	Sg	δ^2 +(P+2) x ($\frac{1}{p-1}$) $\sum$ gi^2
SCA	$\frac{p(p-1)}{2}$	Ss	$\delta^2 + \frac{2}{p(p-1)} \sum\sum_{1\leq j} Sij$
Error	m	Se	δ^2

Table 1: ANOVA for GCA and SCA according to Griffing's method 2

of the *i-th* female line and the *j-th* male line, and e_{ijk}= is the experimental error.

ANOVA for GCA and SCA was evaluated as presented in Table 1.

Where, Sg= $\frac{1}{p+2}\left[\sum(T_{i.}+ii)^2-\frac{4}{p}GT_{..}^{\ 2}\right]$

Ss =

$$\sum\sum y_{ij}^2-\frac{1}{n+2}\sum(T_{i.}+ii)^2+\frac{2}{(p+1)x(p+2)}GT_{..}^{\ 2}$$

Where:

p- Number of parents involved

m- Error of degree freedom

T+ ii =Total rows + value of average parent

GT= Total sum of parent crosses

GCA effect of the inbred line was calculated as following:

gi = $\frac{1}{(p+2)}\left[(Ti+ii)-\frac{2}{p}GT\ \right]$

SCA effect of the cross was calculated as following;

Sij =Sij -

$$\frac{1}{(p+2)}\left[Ti+ii)+(Tj+j\right]+\frac{2}{(p+1)x(p+2)}GT$$

SE = $\sqrt{\frac{2}{p+2}xM'e}$ (calculated for GCA)

SE = $\sqrt{\frac{2p}{p+2}xM'e}$ (calculated for SCA)

Whereas midparent heterosis (MPH) was calculated as:

MPH= $\frac{F1-MP}{MP}$ x 100,

Where:

F_1 is the mean of the F_1 hybrid performance and

MP = $\frac{P1+P2}{2}$

where P_1 and P_2 are the means of the inbred parents. Statistical analyses package were conducted using program MSTAT-C[8], version 2.10.

RESULTS AND DISCUSSION

ANOVA's tests and combining ability for all hybrid combination were significantly different(P≤ 0.01) for ear length and number of rows (Tables 2 and 3). According to our results for ear length (EL) and number of rows per ear (NR/E), the hybrid combination L6xL10 exhibited the maximum EL (22.3 cm/plant) and L5xL9 (19.2 rows/ear), while the minimum values were obtained for hybrid combination L1xL10 (15.9cm/plant) and L7xL10 (14.3 rows/ear). The average value (μ) of EL and NR/E at all studied hybrid combination was 20.4 cm/ear, and 16.7 rows/ ear, while significant differences among extreme values were 6.40 cm/ear and 4.9 rows/ ear. The difference between the mean of all F_1 hybrids and the mean of all parents (F_1-MP) was + 6.06 cm/ear, on the other hand the difference for NR/E was + 2.8 rows/ear. This is due to heterosis of F_1 generations and the effects of additive and non additive genes responsible for the development of EL and NR/E. The coefficient of variation (CV) for all hybrid combinations for EL and NR/E was 4.70 and 5.38%, while SE was 0.91 (EL) and 0.85 (NR/E). The statistical analysis for combining ability indicates that there are significant differences among hybrid combination in both GCA and SCA for EL and NR/E. The ratio between GCA and SCA for EL and NR/E was 0.45 and 2.67. The finding of [11], that besides non-additive effects an important role belonged also to additive variance what was later confirmed [6]. As reported [10] and [12] GCA is preliminary associated with additive effects, whereas SCA is attributed to the non-additive genetic effects. The GCA effects for EL and NR/E consistently showed significant variation between hybrid combinations of parent lines. The highest GCA effect for EL and NR/E was for L7 (+1.122) and L9 (+1.062), indicating that they were good general combiners. The lowest GCA value was obtained by L10 (-0.924) and L4 (-0.744) (Tables 2 and 3). The SCA effects showed by the crosses on the traits that we studied are presented in Tables 6 and 7. The highest value of SCA for EL and NR/E was obtained for combinations L6xL10 (4.125) and L5xL9 (1.865). The lowest value of SCA for EL was obtained for L1xL10 (-2.564), while for NR/E for L7xL10 (-1.69).

Table 2. Ear Length of parents (diagonal, underlined) and their F_1 hybrids (above diagonal)

Line	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	F_1Mean	GCA
L1	12.7	21.2	22.1	22.3	22.2	21.4	21.1	21.8	19.9	15.9	20.8	+0.023
L2		13.1	21.6	20.9	20.9	20.8	21.6	21.5	21.7	17.0	20.7	+0.038
L3			13.2	20.2	20.9	20.0	21.4	21.3	21.5	21.5	20.9	+0.336
L4				17.2	18.1	20.6	19.7	19.2	20.2	19.1	19.4	+0.113
L5					14.7	19.4	18.7	18.6	17.4	16.5	18.1	-0.914
L6						12.2	22.6	19.7	21.3	22.3	21.4	-0.113
L7							18.2	21.8	21.6	20.8	21.4	+1.122
L8								13.1	22.2	20.5	21.3	+0.062
L9									15.2	20.4	20.4	+0.258
L10										14.1	20.0	-0.924
μ value											*20.4*	

LSD $_{p=0.05}$ =1.46,
$_{p=0.01}$ =1.70.

SE(Gi)=0.02
SE(Gi-Gj)=0.04
GCA/SCA=0.45

Table 3. Number of rows per ear of parents (diagonal, underlined) and their F_1 hybrids (above diagonal)

Line	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	F_1Mean	GCA
L1	13.0	14.4	14.3	16.5	17.0	16.5	14.9	16.1	18.3	16.0	16.0	- 0.388
L2		12.0	15.3	15.4	16.4	16.9	15.5	16.2	17.9	15.8	16.5	- 0.536
L3			12.7	16.4	15.9	14.9	15.2	15.3	17.5	15.1	15.8	- 0.743
L4				12.0	14.9	16.6	14.6	14.5	16.6	15.7	15.6	- 0.744
L5					14.7	16.7	15.0	17.4	19.2	17.4	17.9	+ 0.424
L6						15.3	16.3	16.4	16.7	18.2	16.9	+ 0.576
L7							15.3	14.9	17.2	14.3	15.8	- 0.468
L8								15.3	17.7	17.0	17.6	+ 0.154
L9									13.3	18.0	18.9	+ 1.062
L10										15.3	16.0	+ 0.664
μ value											*16.7*	

LSD $_{p=0.05}$ =1.41,
$_{p=0.01}$ =1.69.

SE(Gi)=0.01
SE(Gi-Gj)=0.040

GCA/SCA=2.67

Table. 6 Estimated of SCA effects for Ear Length in a diallel among 10 maize inbred

Parent	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
P_1	-6.76	1.74	2.37	2.56	3.60	2.12	0.55	2.34	0.25	-2.56
P_2	1.74	-6.37	2.12	1.39	2.34	1.44	1.07	1.96	1.87	-1.21
P_3	2.37	2.12	-6.90	0.48	2.08	0.37	0.57	1.53	1.52	2.72
P_4	2.56	1.39	0.48	-2.39	-0.49	1.16	-0.93	-0.37	0.39	0.57
P_5	4.12	2.34	2.08	-0.49	-2.90	1.02	-0.94	0.05	-1.32	-1.06
P_6	2.12	1.44	0.37	1.16	1.02	-7.00	2.22	0.31	1.72	4.12
P_7	0.55	1.07	0.57	-0.93	-0.94	2.22	-3.47	2.38	0.77	1.23
P_8	2.34	1.96	1.53	-0.37	0.05	0.31	2.38	-6.39	2.55	1.99
P_9	0.25	1.87	1.52	0.39	-1.32	1.72	0.77	2.55	-4.71	1.66
P_{10}	-2.56	-1.21	2.72	0.57	-1.06	3.60	1.23	1.99	1.66	-3.28

LSD$_{p\ 0.05}$=0.43
LSD$_{p0.01}$=0.60

SE(sij) = 0.2360
SE(Sij-Sik)=0.51
SE(Sij-Skl)=0.46

Table 7. Estimated of SCA effects for Number of rows per ear in a diallel among 10 maize inbred

Parent	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
P_1	-2.39	-0.53	-0.41	1.86	1.14	0.52	0.006	0.51	1.79	-0.11
P_2	-0.53.	-2.76	0.80	0.84	0.67	0.99	0.63	0.71	1.57	-0.16
P_3	-0.41	0.80	-1.68	2.01	0.41	-0.80	0.57	0.08	1.31	-0.62
P_4	1.86	0.84	2.01	-2.34	-0.58	0.93	-0.02	-0.74	0.41	-0.02
P_5	1.14	0.67	0.41	-0.58	-2.01	-0.13	-0.79	0.98	1.84	0.47
P_6	0.52	0.99	-.0.80	0.93	-0.13	-1.65	0.32	-0.16	0.56	1.09
P_7	0.006	0.63	0.57	-0.02	-0.79	0.32	0.43	-0.65	0.77	-1.69
P_8	0.51	0.71	0.08	-0.74	0.98	-0.16	-0.65	-0.81	0.58	0.31
P_9	1.79	1.57	1.31	0.41	1.84	0.56	0.77	0.58	-4.62	0.40
P_{10}	-0.11	-0.16	-0.62	-0.02	0.47	1.09	-1.69	0.31	0.40	0.16

$LSD_{p\ 0.05}$=0.38
$LSD_{p0.01}$ =0.52

SE(sij) = 0.20
SE(Sij-Sik)=0.44
SE(Sij-Skl)=0.40

CONCLUSIONS

Maize inbred lines exhibited high genetic variability for agronomic traits. L7 and L3 showed higher values for GCA for EL and L9 and L10 for NR/E, while L6xL10 and L5xL9 combinations showed highest values for SCA. The investigation suggests that the some of maize inbred line have good potential to be successively used for plant breeding.

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