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Overall GCA, SCA and Heterotic Status of Maize (*Zea mays* L.) Inbreds and Hybrids

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ABSTRACT

The success of a maize hybrid depends on parental lines with good combining ability to develop stellar hybrids: two inbred parental lines with desirable characteristics should combine into a hybrid. Hence, selection of parents based on combining ability is crusial in producing superior hybrids. Fifteen $F_{3.4}$ inbred lines selected based on narrow Anthesis-Silking Interval (ASI) (0 days) and high grain yield (20 g plant^{-1}) and four testers (MAI-264, MAI-105, MAI-137 and MAI-215) constituted the basic genetic material. Data of F_1 hybrids were subjected to combining ability analysis following line × tester linear model. Analysis of variance for combining ability indicated that crosses differed significantly from one other for all the traits. It is evident from the results that more than 50 per cent of the lines (eight inbreds) were found to be overall good general combiners for all the traits studied. Thirty-four out of 60 hybrids displayed high overall heterotic status and nearly 50 per cent of crosses recorded high overall sca status.

Key words: *Inbreds, Maize, Hybrid, GCA, SCA*

INTRODUCTION

Globally, hybrids as cultivar option have played a vital role in increasing productivity of maize. Single cross maize hybrids have been established as the most heterotic of all the hybrid types and hence, are used for commercial production of maize in most parts of the world.

The success of a maize hybrid depends on how good the parental lines are to develop stellar hybrids; two inbred parental lines with desirable characteristics should combine into a hybrid. Hence, selection of parents/inbreds based on combining ability is very vital in producing superior hybrids. The concept of general combining ability (*gca*) and specific combining ability (*sca*)[10] is a widely accepted criterion for assessing the inbreds for using them as parents in the development of heterotic hybrids.

Testing of inbred lines for their combining ability during early (F_4) stages of their development help save substantial resources concerning time, labour and land resources[4,5] .

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Early generation testing enables plant breeders to discard most of the undesirable inbreds and allows the greater expenditure of resources on most promising ones and identifies those that are desirable for the production of superior hybrids[4,2,1]. Under these premises, an attempt was made to arrive at a simple and rational criterion for choosing the parents for developing high frequency of heterotic hybrids.

MATERIAL AND METHODS

Basic material: Fifteen $F_{3.4}$ inbred lines selected based on narrow Anthesis-Silking Interval (ASI) (0 days) and high grain yield (20 g plant^{-1}) and four testers (MAI-264, MAI-105, MAI-137 and MAI-215) constituted the basic genetic material. These 15 inbred lines were derived from the cross between MAI-349 and BGD-89 which are contrasting for ASI and grain yield potential.

***Development of experimental material*:** The 15 F_4 inbreds were crossed with the four testers following line × tester mating design[7]to develop 60 single cross hybrids (SCH) during summer 2017 at the experimental plots of the Department of Genetics and Plant Breeding (GPB), University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru. The resultant 60 SCH, their parents and four checks *viz*., NAH 2049, NAH 1137, MAH 14-5 and Bio 9544 constituted the experimental material.

Field evaluation of experimental material: The SCH and four check hybrids were evaluated twice at the experimental plots of department of GPB, UAS, GKVK, Bengaluru during 2017 rainy season and 2017 post-rainy season following simple lattice design. The parents were also evaluated twice in two-replicated randomized block design. Each entry was sown in two-rows of 3m length with a spacing of 0.6 m × 0.3 m. Recommended package of practices were followed to raise a healthy crop.

Sampling of plants and data collection: Data were recorded on ten randomly selected plants in each hybrid, parents and checks for days to anthesis, days to silking, ASI, plant height, cob length, cob girth, kernel rows cob^{-1}, kernels row^{-1}, 100 seed weight, and grain yield plant^{-1}.

Statistical analysis: The replicated mean data of hybrids, parents and checks pooled over the two seasons was used for statistical analysis. Data of F_1 hybrids were subjected to combining ability analysis following line × tester linear model (Kempthorne, 1957). The *gca* effects of 15 lines and four testers and sca effects of 60 F_1 hybrids and variances due to gca and sca effects were estimated. The statistical significance of gca and effects were examined using't' test. Mid-Parent Heterosis (MPH) of 60 F_1 hybrids was estimated for each of the ten characters.

As quantitative traits are correlated either positively or negatively, it is usual to find, for a particular parent and a hybrid, gca effects and sca effects, MPH, respectively, in the desirable directions for traits of interest. Hence, the overall status of parents with respect to their gca effects and the hybrids with respect to their sca effects and MPH across ten traits were determined.

The estimates of gca effects of parents, and sca effects and MPH of hybrids were ranked by assigning lowest rank for the parent or the cross which manifested the highest gca/sca effects and MPH, respectively in the desirable direction. The highest rank was assigned for parent or the cross which manifested the lowest gca/sca effects and MPH, respectively, in the desirable direction. The ranks obtained by the parent/hybrid were summed up across all the characters to arrive at a total score for each of the parent/cross. Further, the mean of the total scores of all the parents or crosses across the traits was computed which was used as the final norm to ascertain the status of a parent or a hybrid for their gca/sca effects and MPH.

The parent/hybrid whose total rank exceeded the final norm was given low (L) overall gca/sca/MPH status, respectively. On the other hand, the parent or a hybrid, whose total rank was less than the final norm was given high (H) overall gca/sca/MPH status, respectively. Based on the overall gca status of parents, crosses were classified into HH (both the parents in a cross with high overall gca status), HL (one parent with high and the other parent with low overall gca status) and LL (both the parents with low overall gca status) categories.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA): Analysis of variance (Table 1) for combining ability indicated that crosses differed significantly from one other for all the traits. The lines and testers differed significantly for days to anthesis, days to silking, ASI, plant height, cob length, kernel rows cob^{-1}, kernels row^{-1}, 100 seed weight and grain yield plant^{-1}. A highly significant mean square due to line × tester interaction for all the traits suggested that combining ability of inbred lines differed based on the tester involved in the cross combination which is amply reflected by the crosses which differed significantly from each other. The mean squares attributable to lines were larger in magnitude than those of testers and line × tester for all the quantitative traits except plant height, cob girth and kernel rows cob^{-1} indicating greater contribution of the lines towards the total variation in the hybrids. Kanagarasu *et al.*[6] and Liaqat *et al.*[8], have also reported similar results.

Overall status of *gca* effects

As could be seen from the results on *gca* effects, no single line or tester was a good general combiner for all the characters studied. Consequently, ascertaining the status of a parent for its gca over a number of traits assumes importance. Hence, the lines and testers were classified as high (H) and low (L) overall general combiners[3]. It is evident from the results (Table 2) that more than 50 *per cent* of the lines (eight inbreds) were found to be overall good general combiners for all the traits studied. Our results are similar to those of Niyonzima *et al.*[9]. The testers, MAI 264 and MAI 215 recorded high overall gca status suggesting their greater ability to transmit additive genes with increasing effects for all the ten quantitative traits. From these results, it is apparent that identification of superior combining genotypes early in the course of inbreeding help the breeder to divert more resources towards the most desirable ones.

Overall sca and heterotic status of crosses

Since the overall status of a cross provides a holistic idea on its performance across all the characters, the overall status of a cross for *sca* effects was determined[3]. Nearly 50 *per cent* of crosses (29) recorded high overall sca status (Table 3). Thirty-four out of 60 hybrids displayed high overall heterotic status (Table 4). Based on *sca* effects, the crosses were classified into H × H, H × L and L × L. The predominance of H × L type of crosses indicated the presence of non-additive gene action, suggesting the usefulness of population improvement approach to isolate superior genotypes in the segregating generations derived from these crosses. Niyonzima *et al.*[9] also reported that nearly 50 *per cent* of the hybrids exhibited high overall *sca* status across the characters.

Table 1: Analysis of variance for combining ability for grain yield and its components

Source of variation	Degrees of freedom	Days to anthesis	Days to silking	ASI (Days)	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Kernel rows cob^{-1}	Kernels row^{-1}	100 Seed weight	Grain yield plant^{-1} (g)
Replication	1	0.02	0.07	0.02	154.28	6.59	2.17	1.56	13.83	38.68	55.36
Crosses	59	8.99**	768.23**	02.06**	768.23**	12.25**	5.30**	4.91**	51.80**	31.00**	1299.24**
Lines	14	25.07**	42.10**	02.43**	1611.33**	23.80**	4.39	12.90**	206.39**	81.29**	3997.71**
Testers	3	11.69*	7.70	0.57	2258.14**	4.87	5.39	30.61	7.80	21.83*	1357.24**
Line × Tester	42	7.13**	11.27**	01.82**	487.36**	11.3**	4.25	2.70**	43.70**	20.88**	1082.43**
Error	156	3.58	5.19	0.81	35.54	5.81	2.82	0.57	15.93	7.32	99.05

*Significant @ P=0.05 **Significant @ P=0.01

Table 2: General combining ability status of lines and testers

Codes of F_4 lines	Rank	Status
33	101	H
42	80	H
51	125	H
65	122	H
81	159	L
82	140	L
90	126	H
139	165	L
163	162	L
188	180	L
205	173	L
213	99	H
221	64	H
238	136	L
265	130	H
Testers		
MAI 264	134	L
MAI012	142	L
MAI105	124	H
MAI215	119	H

Final norm: 129

H = High overall GCA status of crosses

L = Low overall GCA status of crosses

Table 3: Specific combining ability status of test crosses

Codes of F_4 lines	MAI 264		MAI 012		MAI 105		MAI 215	
	Score	Status	Score	Status	Score	Status	Score	Status
33	451	L	339	H	394	H	333	H
42	317	H	509	L	378	H	348	H
51	459	L	505	L	264	H	360	H
65	468	L	399	L	403	L	352	H
81	384	H	539	L	475	L	406	L
82	477	L	191	H	366	H	457	L
90	355	H	402	L	321	H	373	H
139	396	H	483	L	526	L	491	L
163	419	L	358	H	459	L	277	H
188	549	L	439	L	384	H	323	H
205	450	L	334	H	167	H	402	L
213	309	H	310	H	289	H	302	H
221	336	H	426	L	332	H	584	L
238	469	L	286	H	455	L	490	L

Final norm: 396.5

H = High overall SCA status of crosses; L = Low overall SCA status of crosses

Table 4: Overall heterotic status of hybrids

Coded F_4 lines	Testers			
	MAI 264 (L)	MAI 012 (L)	MAI 105 (H)	MAI 215 (H)
33 (H)	324	421	380	280
	H	L	L	H
42 (H)	291	273	228	158
	H	H	H	H
51 (H)	350	442	303	331
	L	L	H	H
65 (H)	419	464	325	308
	L	L	H	H
81 (L)	335	423	465	287
	H	L	L	H
82 (L)	242	327	311	233
	H	H	H	H
90 (H)	402	469	418	369
	L	L	L	L
139 (L)	209	261	299	250
	H	H	H	H
163 (L)	355	430	346	258
	L	L	L	H
188 (L)	262	452	252	329
	H	L	H	H
205 (L)	338	339	371	198
	L	L	L	H
213 (H)	330	337	254	254
	H	L	H	H
221 (H)	328	281	347	282
	H	H	L	H
238 (L)	334	396	306	267
	H	L	H	H
265 (H)	477	483	441	486
	L	L	L	L

Final norm: 335.5

H = High overall heterotic status of crosses; L = Low overall heterotic status of crosses

(H) = High overall gca status of parents; (L) = Low overall gca status of parents

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