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COMBINING ABILITY FOR GRAIN YIELD AND ITS COMPONENT TRAITS IN MAIZE (*Zea mays* L.)

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Per se performance

ABSTRACT

Testing of inbred lines for general combining ability (*gca*) enables plant breeders to discard undesirable ones and identify those that are desirable for the production of superior hybrids. In this context, 16 inbred lines were selected on the basis of grain yield and were evaluated for their *gca* related to grain yield plant^{-1} and its attributing traits. The analysis of variance revealed significant differences among the inbred lines for their *per se* performance as well as their *gca*. Similarly the hybrids differed significantly for *per se* performance and their specific combining ability (*SCA*) effects for all the traits. Five of the 16 inbred lines were identified as good general combiners for grain yield plant^{-1}. Non-significant correlation between *per se* performance and *gca* effects suggested that *per se* performance of inbred lines is not a good indicator of their *gca* effects for any of the traits. However, significant positive and fairly high magnitude of correlation between *per se* performance of hybrids and sum of parental *gca* effects indicated good predictability of hybrids *per se* performance based on their parental *gca* effects for all the traits investigated.

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1 Introduction

Single cross hybrids are the major cultivar types used for commercial production of maize in most parts of the world. Hybrids have played a vital role in increasing the area and productivity of maize. Superior hybrids are produced if the parents involved have good general combining ability (*gca*), which is the relative ability of a genotype to transmit its genes with additive effects to its progeny. The concept of *gca* (Sprague &Tatum, 1942) is a widely accepted criteria for assessing the inbreds for their use as parents in the development of heterotic hybrids.

Testing of inbreds for their *gca* effects enables plant breeders to discard most of the undesirable inbreds and allows greater expenditure of resources on most promising ones and identifies those that are desirable for the production of superior hybrids (Bernardo, 2010; Ali et al., 2011; Ai-Zhi & Zheng, 2012; Fasahat et al., 2016; Hosana et al., 2016). Apart from providing an objective criterion for choosing parents, *gca* also provides useful clues about mode of action of genes controlling economically important traits. Another utility of *gca* of the parents is their predictive power of hybrid *per se* performance in the absence of significant hybrid specific combining ability (*sca)* effects. Under these premises, an investigation was undertaken to assess the *gca* of inbred lines and hybrids of maize

2 Materials and Methods

2.1 Basic material

Based on prior evaluation of 16 inbred lines of maize were selected based on high grain yield, and they constituted the basic genetic material.

2.2 Development and field evaluation of experimental material

These 16 inbreds were crossed following half diallel mating design (Hayman, 1954) to develop 120 single cross hybrids (SCH) during summer 2015 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 120 SCH, their parents and two checks *viz*., Hema and Nithyashree constituted the experimental material and were evaluated following simple lattice design. Each entry was sown in two-rows of 3 m length with a spacing of 0.6 m × 0.3 m. All the recommended package of practices was followed to raise a healthy crop.

2.3 Sampling of plants and data collection

Data were recorded on five randomly selected plants in both the replications, on each hybrid, parent and checks for grain yield plant^{-1} and its attributing traits.

2.4 Statistical analysis

Replication wise mean data of hybrids, parents and checks was used for statistical analysis. Data of F_1 hybrids were subjected to combining ability analysis following diallel model (Hayman, 1954; Griffing, 1956). The *gca* effects of 16 lines were estimated and their statistical significance was examined using ‘t’test.

2.5 Relationship of *gca* effects of inbred lines with their *per se* performance

Relationship between *per se* performance of 16 inbred lines and their *gca* effects were determined by estimating Spearman’s Rank Correlation Coefficient for all the traits. Higher magnitude of positive significant and non-significant correlation indicates good and poor predictive power of *per se* performance, respectively.

2.6 Relationship of hybrid *per se* performance with sum of parental *gca* effects

Pearson’s Correlation Coefficients between hybrids *per se* performance and sum of *gca* effects of their parents were estimated for all traits (Schrag et al., 2009). Significant correlation with fairly high coefficients of correlation and determination was interpreted as high predictability of hybrid *per se* performance based on their sum of parental *gca* effects.

3 Results and Discussion

3.1 Analysis of variance (ANOVA)

ANOVA indicated significant differences among single cross hybrids for all the traits (Table 1). Significant mean squares due to inbreds and hybrids suggested substantial variability for *gca* effects of inbreds and *sca* effects of their crosses for all the traits. Significant variances among the crosses could be attributed to greater diversity between inbreds for the traits considered. The mean squares attributable to inbreds and crosses for all the traits indicated greater contribution of the inbreds towards total variation among the hybrids (Kanagarasu et al., 2010).

3.2 General combining ability of inbred lines

The practical phase of hybrid maize breeding is identification of elite inbred lines with high *gca* for use as parents for developing hybrids that are superior to existing ones (El-Hosary, 2014). Identification of such elite inbred lines is the major strategy adopted by most commercial plant breeders to maximize genetic gain per unit time and resources. This assumption is based on the reports that *gca* is controlled by additive effect genes which control the inheritance of phenotypes that are fixable (Ai-Zhi & Zheng, 2012).

In the present study, the inbred lines differed widely for their *gca* effects for all the Six quantitative traits. The differences in *gca* effects of the inbreds are attributable to differences in frequencies of genes that are transmitted to the progeny with the additive effects (Falconer & Mackay, 1996). The differences in gene frequencies among the inbreds suggest their significant genotypic differences, thus justifying their selection for the present study.

Different inbred lines were desirable general combiners in both direction and magnitude for different traits (Table 2). Thus, no single line was a desirable combiner for all the seven traits. For instance, inbreds such as MQPM 43, 18816, MAI 386, 18701 and 754 were desirable general combiners for only grain yield plant^{-1}, plant height, number of kernel rows^{-1}, ear length and ASI, respectively (Table 2). However, inbred lines MAI 386 and MQPM 43 were good general combiners for four traits, namely ASI, ear length, Kernel row^{-1} and grain yield plant^{-1}. Thus the inbred lines MAI 315, MAI 157 and M2 need greater attention and need to be evaluated on a large scale to confirm their superiority for *gca* effects. It should however be noted that the estimates of *gca* effects of 16 inbred lines are relative to and are dependent on particular set of parents included in the experiment (Fasahat et al., 2016).

Table 1 ANOVA of 16 × 16 half diallel crosses and their parents for grain yield and its component traits in maize

Sources of variation	Degrees of freedom	Anthesis Silking Interval (days)	Ear length (cm)	Ear width (cm)	Kernels rows ear^{-1}	Kernels row $^{-1}$	Grain yield plant^{-1} (g)
Replications	1	2.88	1.26	0.56	0.05	1.13	2152.69
Inbreds + Hybrids	135	1.371**	9.75**	2.03**	32.87**	3.70**	2048.80**
Inbreds	15	0.36	8.02*	2.58**	47.34**	5.13**	1895.80**
Hybrids	119	1.48**	9.85**	1.95**	30.48**	3.37 **	2080.05**
Indreds Vs. Hybrids	1	2.89	23.56*	3.75*	100.14*	20.84 **	625.38
Error	135	0.75	4.47	0.70	15.47	1.12	847.77
Total	271	1.07	7.09	1.37	24.09	2.41	1450.89
GCA	15	1.22**	9.86**	1.39**	24.36**	3.00 **	1867.03**
SCA	120	0.61**	4.25**	0.97**	15.44**	1.70 **	919.07**
Error	135	0.37	2.23	0.35	7.74	0.56	423.88

Table 2 Estimates of general combining ability of 16 inbreds for grain yield and its component traits in maize

Inbreds	Anthesis Silking Interval (days)	Ear length (cm)	Ear width (cm)	Kernels rows ear^{-1}	Kernels row $^{-1}$	Grain yield plant^{-1} (g)
MAI 137	0.43**	-1.46**	-0.40**	-1.35*	-0.42*	-14.51**
MAI 157	-0.38**	-1.03**	0.04	-0.75	-0.19	5.60
MAI 315	-0.34*	0.12	0.17	0.96	-0.72***	12.17*
MAI 327	0.07	-0.06	0.01	-0.68	0.18	1.72
MAI 360	0.31*	-0.13	0.08	-0.10	0.24	5.12
754	-0.41**	-0.52	-0.51**	-1.00	-0.31	-13.63**
18758	-0.08	0.21	-0.34*	-0.17	0.17	-9.97*
18816	0.00	-0.41	0.33*	-1.02	0.77**	-12.3**
M 2	-0.08	0.07	0.28*	-0.17	-0.43*	11.63*
MAI 175	0.30*	-0.12	-0.15	-0.33	0.51**	1.70
MAI 386	-0.27*	1.16**	0.04	2.33**	0.44*	11.85*
MAI 387	0.12	-0.43	-0.29*	-1.96**	-0.31	-14.79**
MQPM 43	0.04	0.92**	0.39**	0.74	-0.01	12.61**
747	-0.07	0.10	0.31*	1.65*	0.38*	2.56
757	0.28*	0.14	-0.04	0.84	-0.11	4.32
18701	0.09	1.43**	0.09	1.02	-0.18	-4.04
Gi – Gj @ 5%	0.434**	1.062**	0.42**	1.976**	0.531**	14.628**
Gi - Gj @ 1%	0.6**	1.468**	0.581**	2.732**	0.734**	20.223**

* Significance at P = 0.05;**Significance at P =0.01

3.3 Relationship of gca effects of inbred lines with their *per se* performance

Significant positive but low magnitude of correlation between *per se* performance of the inbreds and their *gca* effects for ASI, ear length, ear width, kernels rows^{-1}, Kernel rows ear^{-1} (Figure 1-6), suggested that *per se* performance of the lines is not a good indicator of their *gca* effects for any of the traits. The poor correlation between *per se* performance and *gca* effects of inbred line could be attributable to different sets of genes controlling *per se* performance and *gca* effects for target traits (Turner, 1953;

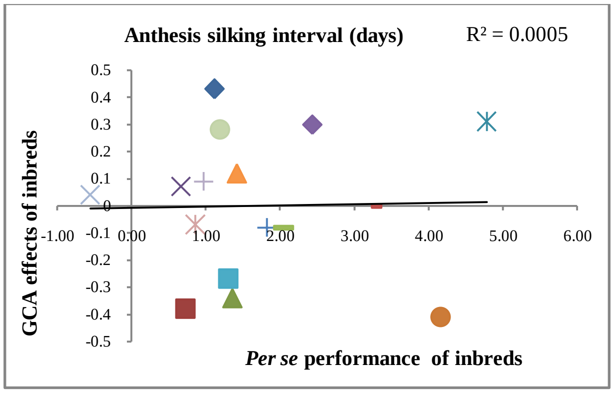

Figure 1 Correlation between *per se* performance and gca effects of inbreds for anthesis silking interval (days)

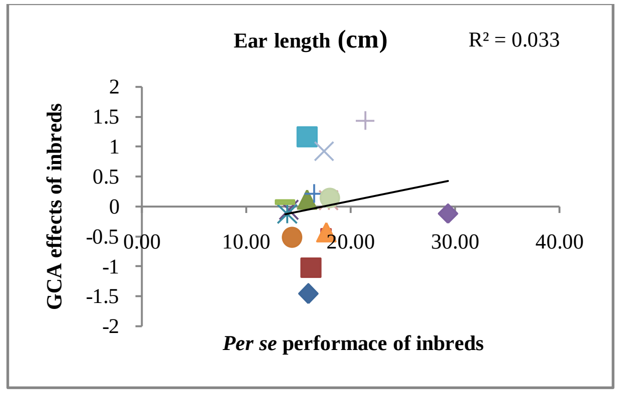

Figure 2 Correlation between *per se* performance and gca effects of inbreds for ear length (cm)

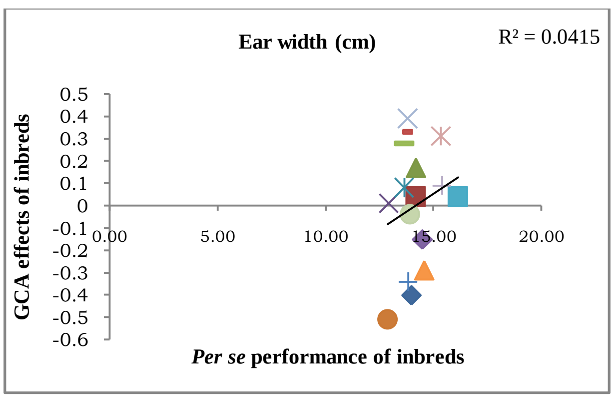

Figure 3 Correlation between *per se* performance and gca effects of inbreds for ear width (cm)

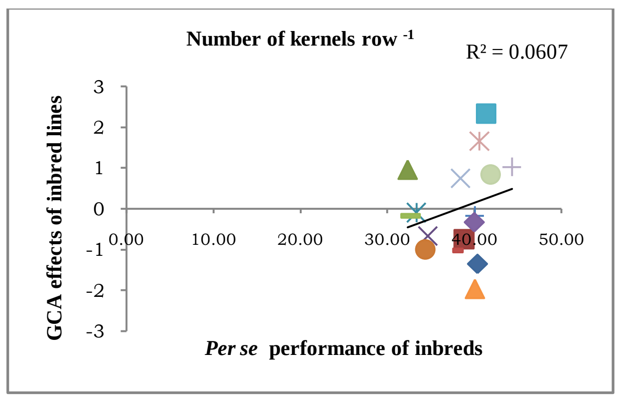

Figure 4 Correlation between *per se* performance and gca effects of inbreds for kernels row^{-1}

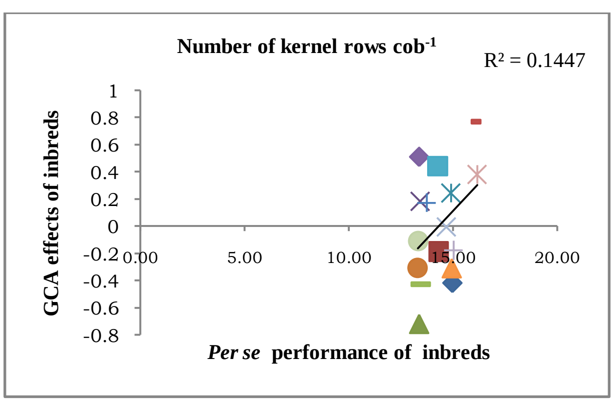

Figure 5 Correlation between *per se* performance and gca effects of inbreds for kernel rows cob^{-1}

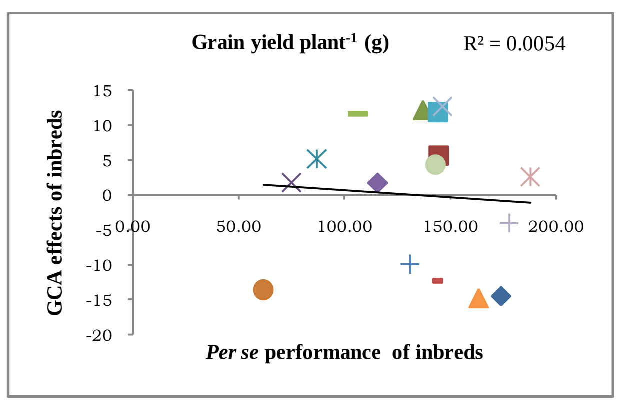

Figure 6 Correlation between *per se* performance and gca effects of inbreds for grain yield plant^{-1} (g)

Ai-Zhi & Zhang, 2012). Significance of mean squares attributable to gca and sca (Table 1) provide evidence for the involvement of both additive genetic variance and dominance genetic variance for the expression of grain yield plant^{-1} and its attributing traits.

3.4 Relationship of hybrid *per se* performance with sum of parental gca effects

Relatively high magnitude of correlation between sum of the parental *gca* effects with hybrid *per se* performance for all the traits (Figure 7-12), suggested that parental *gca* effects retained

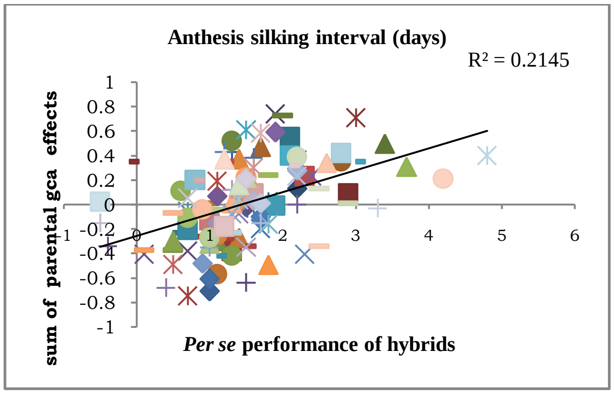

Figure 7 Correlation between *per se* performance of hybrids and sum of parental gca effects for anthesissilking interval (days)

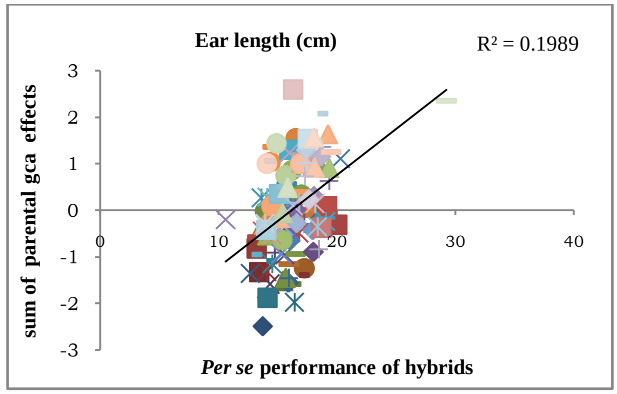

Figure 8 Correlation between *per se* performance of hybrids and sum of parental gca effects for ear length (cm)

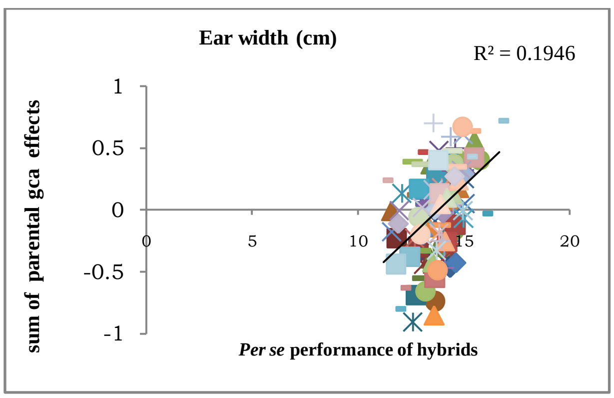

Figure 9 Correlation between *per se* performance of hybrids and sum of parental *gca* effects for ear width (cm)

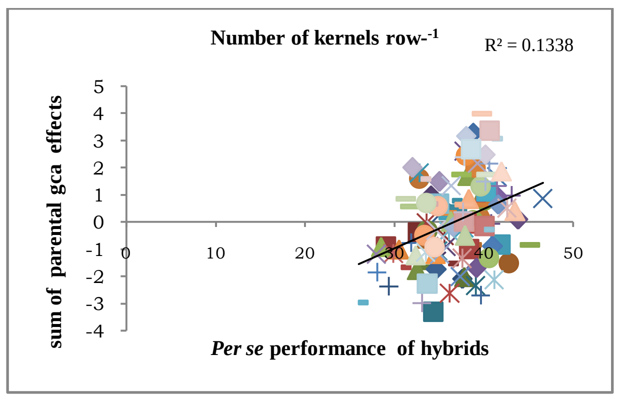

Figure 10 Correlation between *per se* performance of hybrids and sum of parental *gca* effects for kernels row^{-1}

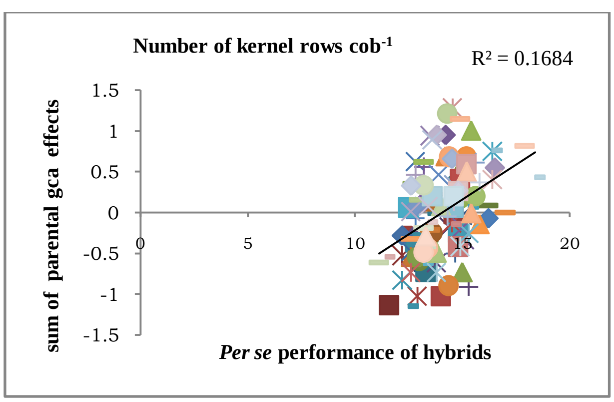

Figure 11 Correlation between *per se* performance of hybrids and sum of parental gca effects for kernel rows cob^{-1}

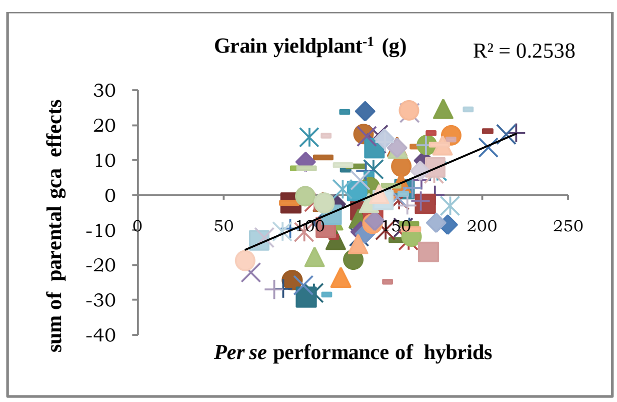

Figure 12 Correlation between *per se* performance of hybrids and sum of parental gca effects for grain yield palnt^{-1} (g)

fairly higher predictability of hybrid *per se* performance. It helps to predict hybrids performance based on their parental *gca* which is attributable to additive effect genes (Falconer & Mackay, 1996). Prediction of hybrid heterosis based on parental *gca* effects would save substantial resources as it enables the evaluation of only a few hybrids that are predicted to be most promising ones. The utility of parental *gca* effects for predicting hybrid *per se* performance has also been reported by Schrag et al. (2009) and Sowmya & Gangappa (2018).

Conclusion

From this study it is evident that the correlation between *per se* performance of hybrids and sum of parental *gca* effects will help in predicting the hybrids *per se* performance based on their parental *gca* effects for all the traits investigated, Hence, *gca* of parents can be used as a predictive tool for developing hybrids with superior *per se*, which in turn helps in reducing the use of input resources and enhances the breeding efficiency.

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Conflict of Interest: Nil

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