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COMBINING ABILITY ANALYSIS OF EAR CHARACTERISTICS OF SWEET CORN HYBRIDS SUITABLE FOR ORGANIC CROP PRODUCTION

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ABSTRACT

Good knowledge of genetic merits governing the inheritance of economic traits is of paramount importance to plant breeders for crop improvement. Objectives of the study were to investigate the genetic nature of ear traits in sweet corn (*Zea mays* convar. *saccharata* var. *rugosa)* based on the general and specific combining ability (GCA and SCA) analysis, and to determine the breeding potential of eight promising inbred lines for the development of new hybrid cultivars well suited for organic production. Thirty-six genotypes (hybrid families) derived from a half diallel cross design were grown under organic crop management at three agro-ecological zones of the tropics. Although the genotypes varied significantly for all the observed ear traits, some of them showed clear inconsistencies in performing husked ear size (length, diameter, and weight), kernel row number, and kernel number per row across environments. The combining ability analysis showed that additive gene action was more preponderance than non-additive gene actions in governing the inheritance of the studied ear traits. The inbred lines: Caps 5, Caps 17A, Caps 17B, and Caps 22 showed their potential as good partners for the improvement of ear performances as to the development of superior sweet corn cultivars for organic production.

Keywords: sweet corn, ear characteristics, half diallel, general combining ability, specific combining ability, organic crop management

INTRODUCTION

Sweet corn (*Zea mays* convar. *saccharata* var. *rugosa*) is a warm climate plant and cultivated year-round in the tropics. It is also well adapted to nearly all types of soil, although a great effort may be needed to attain a feasible crop production. The increasing enthusiasm on the organic sweet corn production among the growers to a large extent was driven by the trend in consumers' demand for organic products and the rising public concern on the environmental issues. Some studies on the crop management have been performed to improve the sweet corn productivity and quality under the organic environment (O'Sullivan et al. 2015; Waghmode et al. 2015; West et al. 2016; Muktamar et al. 2017). Similarly, some breeding efforts intended to develop sweet corn cultivars best suited for organic production have been conducted (Myers et al. 2012; Shelton & Tracy 2013), but the number of released cultivars is still insufficient to meet the growing demand. Consequently, most of the organic sweet corn growers have to use the cultivars bred for conventional production. Such cultivars were developed to gain the highest crop productivity by involving a heavy use of agrochemical products, and they do not always perform well under the requirements of organic farming crop management (Efthimiadou et al. 2009; Lazcano et al. 2011; Murmu et al. 2013).

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Sweet corn for fresh market is commonly sold by the piece and graded accordingly to ear quality. Consequently, the improvement of ear yield and quality is a crucial objective in the sweet corn breeding program (Erdal et al. 2011; Srdić et al. 2016). In this regard, a study on the inheritance patterns of yield and quality is necessary to give a scientific basis for the selection strategies adopted in developing of new sweet corn cultivars for organic production.

Various mating designs are available for revealing the inheritance pattern of quantitative traits through the evaluation of progenies. The analysis of data generated from the mating project can be used to explain the nature of the genetic control of the trait, as well as to help the breeder compose the basic population for the development of new cultivars (Acquaah 2012). Among the mating projects, diallel cross design (Griffing 1956a, b) is used quite commonly in sweet corn breeding (Ozlem et al. 2013; Teixeira et al. 2014; Suzukawa et al. 2018). The estimated general combining ability (GCA) and specific combining ability (SCA) generated from the diallel analysis serve as a measure for the roles of additive and non-additive gene action – domination and epistasis, respectively (Sprague & Tatum 1942). In the plant breeding program, the estimation of GCA effects helps breeders to decide for the promising parents involved in hybridization, while the estimation of SCA effects supports in the selection of best cross combinations (Ferreira et al. 2018).

The study was carried out to estimate the combining abilities (GCA and SCA) and other related genetic parameters for ear traits of the thirty-six hybrid families obtained from a half diallel cross of eight promising inbred lines of sweet corn grown under the organic crop management in three agro-ecological zones in the tropics. The study was also aimed to determine the best combination partners among these inbred lines for the development of new sweet corn cultivars well suited for organic production.

MATERIALS AND METHODS

The study was conducted in 2017 at three locations in Bengkulu Province, Indonesia to represent highland, midland, and lowland agro-ecological zones of the tropics. The highland experiment took place at Air Duku, Rejang Lebong Regency (lat. 3°27'34″ S, long. 102°36′54″ E, alt. 1054 m asl), with the diurnal air temperature ranging from 14 to 25 °C, the annual precipitation 2965 mm, inceptisol soil type, and soil pH 5.5. The midland experiment was located at Sukarmarga, Rejang Lebong Regency (lat. 3°29′40″ S, long. 102°30′33″ E, alt. 618 m asl), with the diurnal air temperature ranging from 17 to 28°C, the annual precipitation 2429 mm, inceptisol soil type, and soil pH 5.3. The lowland experiment was carried out in the coastal area of Bengkulu City (lat. 3°45′14″ S, long. 102°16′58″ E, alt. 10 m asl), with the diurnal air temperature ranging from 23 to 32°C annual precipitation 3360 mm, organosol soil type, and soil pH 4.7.

Thirty-six sweet corn genotypes – eight parental inbreds (Caps 2, Caps 3, Caps 5, Caps 15, Caps 17A, Caps 17B, Caps 22, and Caps 23) and twenty-eight hybrid families – obtained from the 8 × 8 half diallel cross design (according to Griffing's method II; Griffing 1956b) were used in this study. The inbred lines were developed from a series of selection trials under organic crop management up to seven generations of selfing (S_7). In each location, the genotypes were allotted on the experimental plots according to randomized complete block design with three replications. The experimental plots consisted of five-meter single rows spaced 75 cm apart.

The seeds of each genotype were sown directly in the respective row with 25 cm plant-to-plant spacing. The basal organic fertilizer consisted of 15 tons of cow manure per hectar was applied during the soil preparation. Side dressings of a locally made liquid organic fertilizer (Fahrurrozi et al. 2016) were implemented four times during the plant growth period at two weeks interval. No synthetic chemical pesticides were involved in controlling weeds, pests, and diseases. Handpicked harvest was carried out at about 25 days after silking as the ears had fully developed, silks turned brown, and husk turned dark green.

Data were collected from samples of fifteen plants selected randomly from the middle part of the row for unhusked and husked ear characteristics (length, diameter, and weight), kernel row number, kernel number per row, and total soluble solids content. DIALLEL.SAS 05 program developed by

Zhang et al. (2005) was employed to perform both combined analysis of variance across the environments and genetic parameter estimation in accordance to Gardner & Eberhart's analysis III (Gardner & Eberhart 1966). F-tests for the mean squares of the main effect, i.e., environment (E), block within environment (block/E), and genotype (G) along with its partitions were tested against the mean square of genotype by environment interaction (G × E), while the mean squares of the remaining interaction terms were tested against the mean square of the pooled error. The mean separation among the genotypes was performed using the Scott–Knott test (Scott & Knott 1974) according to DSAASTAT (Onofri 2010). The general predictability ratio (GPR) was calculated according to Baker (1978).

RESULTS AND DISCUSSION

The overall performances of the ear traits observed on the breeding materials indicated that sweet corn could grow well under the organic crop management across three agro-ecological zones (Table 1). These performances were comparable to those reported by Kashiani et al. (2010, 2014) and Santos et al. (2014) where synthetic chemical products were introduced in crop management. Our results confirmed that in most cases, plants in the midland and highland appeared producing better ear performances than their counterparts in the lowland, notably for both unhusked and husked ear weight. However, the reversed situations were observed on the number of days to plant maturity (data are not shown), where plants tended to set tassel and silk earlier along with the decreasing altitudes.

The mean squares resulting from the combined analysis of variance across the experimental sites for the nine traits studied are presented in Table 2. Environmental effect (E) and genotypic effect (G) had significant influences on all traits, indicating that both the environment and the genetic constitution of the breeding materials contributed prominent roles in the whole ear characteristics. Moreover, the existence of the significant effect of genotype by environment (G × E) interaction for husked size (ear length, diameter, and weight), kernel-row number, and kernel number per row implied that the genotypic ranks for these traits were inconsistent across environments. The different response of sweet corn genotypes in different environments was common (Ardelean et al. 2012), and the existence of G × E interaction was significant in the plant breeding for developing cultivars with adequate adaptation to the targeted environment (Ceccarelli 2015).

The partitioning of the genotypic effect showed that the parental inbred (P) component was significant for unhusked and husked ear length and unhusked ear weight. The mean performances of the parental inbreds are presented in Table 3. Caps 17A and Caps 17B showed their superiority for unhusked and husked ear length. Caps 17B had also shared its superiority with Caps 5 on unhusked ear weight. Likewise, the inbred vs. hybrid (P vs. H) and hybrid (H) components were significant for all traits, except kernel row number. For comparison to the parental performances, the mean ear characteristics of the hybrid families are presented in Table 4. It is worth emphasizing that the hybrids outperformed their respective parental inbreds with some exception found for total soluble solids content, where most of the hybrids contained lower amount of this compound, or they were less sweet. The exceptions were found on the following hybrid families: Caps 3 × Caps 15 (P3 × P5), Caps 5 × Caps 17B (P3 × P6), Caps 5 × Caps 22 (P3 × P7), Caps 15 × Caps 17B (P4 × P6), and Caps 17B × Caps 22 (P6 × P7), which had higher total soluble solids content than the corresponding parental inbreds.

The outperformance of hybrids over their parental inbreds were a good phenotypic indicator of the existence of heterosis phenomenon. This superiority was accented by the significance of the average heterosis for most of the traits. What is more, the average heteroses of all tested traits (except total soluble solids content) were in a positive direction, implying that the phenomenon of heterosis in the desired direction could be further exploited for the development of hybrid cultivars. The existence of heterosis phenomenon in sweet corn is well established, and it has been reported by several studies (Saleh et al. 1993; Assunção et al. 2010; Srdić et al. 2011; Solomon et al. 2012).

Table 1. The overall performances of thirty-six sweet corn genotypes grown organically at three agro-ecological zones in the tropics

Traits	Highland				Midland				Lowland			
	min	max	mean	CV (%)	min	max	mean	CV (%)	min	max	mean	CV (%)
Unhusked ear length (cm)	17.9	34.2	27.3	10.4	20.4	35.0	28.3	9.5	21.3	32.2	26.1	9.5
Unhusked ear diameter (mm)	37.8	67.8	59.7	8.7	50.1	68.0	61.1	6.7	36.4	75.8	57.1	9.9
Unhusked ear weight (g)	138.3	516.2	380.7	19.1	209.2	496.8	375.6	17.0	69.0	549.5	319.1	26.1
Husked ear length (cm)	13.6	23.6	18.4	10.7	14.2	22.8	18.2	8.6	10.9	22.4	17.9	12.0
Husked ear diameter (mm)	30.7	60.3	49.8	8.7	38.2	58.2	50.8	7.0	31.3	61.1	47.8	9.9
Husked ear weight (g)	86.7	343.4	250.9	20.4	120.2	359.8	247.5	19.3	28.8	396.4	215.3	30.9
Kernel-row number	12.4	18.0	15.1	7.6	11.5	18.4	15.0	8.2	8.5	18.8	14.7	11.2
Kernel number per row	25.4	44.0	36.1	12.4	23.2	46.4	34.6	14.1	12.0	44.6	32.1	21.8
Total soluble solids content (°Brix)	10.0	17.0	12.9	11.1	9.0	16.0	13.2	11.1	7.0	16.0	12.6	12.5

Table 2. Mean squares from a combined analysis of variance for the ear traits of thirty-six sweet corn genotypes grown organically at three agro-ecological zones in the tropics

Source of variation	DF	Mean square								
		unhusked ear			husked ear			kernel-row number	kernel number per row	total soluble solids content
		length	diameter	weight	length	diameter	weight			
Environment (E)	2	105.68**	453.39**	126132.50**	6.51**	259.77**	41735.27**	6.17**	452.86**	12.73**
Block/E	6	21.73**	18.14 ns	2346.91 ns	1.81 ns	22.18*	1177.43 ns	1.28 ns	12.70 ns	12.83**
Genotype (G)	35	31.83**	127.56**	32425.99**	22.28**	80.88**	19072.48**	9.20**	181.09**	4.30**
Parental (P)	7	34.42**	69.50 ns	12103.18*	16.75**	49.57 ns	5433.74 ns	4.61 ns	68.83 ns	3.71 ns
P vs H	1	328.94**	3078.74**	834643.06**	368.57*	1858.79*	476869.00*	89.03 ns	4061.31*	5.93**
Hybrid (H)	27	20.16**	33.30**	7983.12**	10.89**	23.15**	5653.02**	7.44 ns	66.48**	4.40**
GCA	7	56.37**	69.96**	19426.17**	29.18**	55.22*	16859.73**	20.80**	160.09**	8.35*
SCA	20	7.48 ns	20.47*	3978.05*	4.50**	11.93*	1730.67 ns	2.77**	33.71**	3.01**
G × E	70	7.85 ns	14.79 ns	2659.66 ns	1.71*	12.88*	1574.69*	1.38**	19.03**	1.87 ns
P × E	14	6.77 ns	28.62**	4276.25**	3.57**	24.42**	2564.46**	2.06**	26.66**	1.99 ns
P-H × E	2	1.63**	30.87 ns	6202.13*	10.80**	50.21**	8630.73**	7.43**	199.00**	0.02 ns
H × E	54	8.36 ns	10.61 ns	2109.34 ns	0.89 ns	8.50 ns	1056.75 ns	0.98 ns	10.39 ns	1.90 ns
GCA × E	14	11.5 ns	15.22 ns	2591.50 ns	0.82 ns	14.63 ns	1358.18 ns	1.30 ns	8.65 ns	2.18 ns
SCA × E	40	7.23 ns	9.00 ns	1940.58 ns	0.92 ns	6.36 ns	951.26 ns	0.87 ns	11.00 ns	1.81 ns
Pooled Error	210	7.81	12.00	1966.95	1.25	8.83	1023.10	0.78	10.38	1.70
GCA:SCA		7.53	3.42	4.88	6.49	4.63	9.74	7.51	4.75	2.77
GPR		0.94	0.87	0.91	0.93	0.90	0.95	0.94	0.90	0.85
Avg. heterosis		2.42**	7.41**	122.08**	2.57**	5.76**	92.28**	1.26**	8.52**	-0.33 ns

*,** statistically significant at 5% and 1 %, respectively, ns – non-significant

Table 3. Mean performances of the ear traits observed from the eight sweet corn parental inbreds grown organically at three agro-ecological zones in the tropics

Parent	Unhusked ear			Husked ear			Kernel-row number	Kernel number per row	Total soluble solids content (°Brix)
	length (cm)	diameter (mm)	weight (g)	length (cm)	diameter (mm)	weight (g)			
Caps 2 (P1)	24.0 b	51.5	230.2 b	15.6 c	45.1	152.4	12.8	25.2	13.3
Caps 3 (P2)	23.4 b	52.3	241.6 b	14.7 d	43.7	142.2	14.8	26.3	13.4
Caps 5 (P3)	24.9 b	58.2	300.9 a	16.1 c	50.4	215.5	13.4	26.0	12.0
Caps 15 (P4)	25.2 b	53.7	256.6 b	16.1 c	45.1	166.6	13.9	30.3	13.9
Caps 17A (P5)	28.0 a	52.9	272.1 a	17.5 b	42.9	161.4	14.7	31.0	13.6
Caps 17B (P6)	28.6 a	56.3	319.4 a	18.5 a	43.9	181.1	14.0	30.8	12.9
Caps 22 (P7)	25.8 b	54.0	278.2 a	16.5 c	45.2	171.2	14.6	27.7	12.4
Caps 23 (P8)	23.6 b	49.3	209.1 b	14.4 d	43.6	138.6	13.4	23.8	13.6

The mean values for the same trait followed by the same letter were not significantly different by Scott-Knott test at 0.05 probability level

Table 4. Mean performances of the ear traits observed from twenty-eight sweet corn cross grown organically at three agro-ecological zones in the tropics

Hybrid	Unhusked ear			Husked ear			Kernel-row number	Kernel number per row	Total soluble solids content (°Brix)
	length (cm)	diameter (mm)	weight (g)	length (cm)	diameter (mm)	weight (g)			
P1 × P2	26.7 b	58.7 b	348.7 c	17.1 d	49.0 b	220.8 b	13.6 c	32.8 c	12.6 b
P1 × P3	26.5 b	59.7 b	358.0 c	18.3 c	51.8 a	253.3 b	13.2 c	32.1 c	12.1 b
P1 × P4	27.7 b	60.0 b	380.5 c	19.1 b	50.5 b	246.7 b	14.9 b	36.8 b	13.7 a
P1 × P5	29.2 a	60.8 b	393.4 b	19.2 b	49.3 b	257.8 b	14.8 b	39.3 a	12.2 b
P1 × P6	28.2 a	59.5 b	364.8 c	18.7 c	49.6 b	238.6 b	13.7 c	36.5 b	13.0 b
P1 × P7	25.8 b	60.5 b	344.1 c	17.0 d	49.6 b	234.3 b	14.2 c	33.0 c	12.3 b
P1 × P8	28.3 a	59.4 b	354.3 c	17.4 d	49.5 b	221.3 b	14.5 b	31.1 c	12.2 b
P2 × P3	26.7 b	64.3 a	399.7 b	17.8 d	53.0 a	269.0 a	15.2 b	36.6 b	12.9 b
P2 × P4	25.6 b	57.8 b	362.5 c	18.2 c	48.0 b	252.5 b	16.0 a	38.4 a	14.1 a
P2 × P5	26.8 b	60.2 b	383.4 c	18.1 c	50.8 b	267.4 a	15.5 b	37.2 b	12.7 b
P2 × P6	27.3 b	61.2 b	383.4 c	18.9 b	50.1 b	254.8 b	15.2 b	36.3 b	12.3 b
P2 × P7	25.5 b	59.4 b	347.8 c	17.2 d	51.0 b	236.0 b	15.2 b	34.2 c	13.6 a
P2 × P8	26.8 b	58.8 b	348.7 c	17.6 d	48.9 b	230.4 b	14.9 b	33.9 c	12.7 b
P3 × P4	28.5 a	59.0 b	395.5 b	19.2 b	50.2 b	276.4 a	15.7 a	37.4 b	13.3 a
P3 × P5	29.1 a	65.7 a	451.4 a	19.8 a	55.0 a	314.1 a	16.2 a	38.9 a	12.1 b
P3 × P6	28.4 a	63.0 a	430.1 a	20.3 a	52.1 a	287.9 a	16.4 a	35.7 b	13.2 a
P3 × P7	25.7 b	62.7 a	405.8 b	18.6 c	53.5 a	290.2 a	14.7 b	35.1 c	13.0 b
P3 × P8	27.4 b	60.2 b	368.9 c	18.2 c	50.4 b	249.6 b	14.9 b	34.0 c	12.3 b
P4 × P5	28.1 a	62.3 a	420.7 a	20.4 a	52.2 a	303.5 a	16.9 a	40.5 a	12.7 b
P4 × P6	28.0 a	58.8 b	376.5 c	20.2 a	49.3 b	250.0 b	15.2 b	35.8 b	14.2 a
P4 × P7	27.5 b	62.0 a	407.1 b	19.0 b	51.6 a	283.2 a	15.9 a	39.1 a	12.9 b
P4 × P8	28.7 a	60.6 b	413.7 b	21.3 a	50.2 b	286.6 a	16.7 a	42.3 a	13.0 b
P5 × P6	32.1 a	60.9 b	385.5 c	19.0 b	49.6 b	251.7 b	15.3 b	36.1 b	12.7 b
P5 × P7	29.0 a	64.0 a	430.1 a	19.5 b	53.4 a	292.2 a	16.5 a	39.5 a	13.3 a
P5 × P8	28.7 a	60.4 b	382.0 c	18.2 c	50.7 b	245.0 b	15.1 b	35.9 b	12.7 b
P6 × P7	30.4 a	63.7 a	434.5 a	20.0 a	49.8 b	254.1 b	15.3 b	37.6 b	13.8 a
P6 × P8	29.5 a	61.8 a	363.7 c	18.4 c	51.2 b	232.7 b	15.2 b	33.3 c	10.9 c
P7 × P8	28.1 a	61.0 b	362.2 c	17.6 d	50.5 b	234.8 b	14.7 b	33.1 c	12.3 b

The mean values for the same trait followed by the same letter were not significantly different by Scott-Knott test at 0.05 probability level

The analysis of combining ability proved that the variation due to GCA effect was significant for all traits, revealing that additive gene action was pronounced in the inheritance of the studied traits. The magnitude and direction of GCA effects of the tested parental inbreds indicated their potency as partners in the development of valuable hybrids (Table 5). In our studies, significant and positive GCA effects were desirable for all observed traits. Caps 17A appeared to be the best partner as it had significant and positive GCA effects for most of the observed traits, except total soluble solids content. Caps 17B was identified a good partner for unhusked ear length and diameter, and husked ear length; Caps 5 was a good partner for unhusked ear diameter and husked ear weight, and Caps 22 was a good partner for unhusked ear diameter.

The variation due to SCA effects was also significant for the studied traits, except for the total soluble solids content, indicating that non-additive gene action (domination and epistasis) was involved in the trait's inheritance (Table 6). In the development of improved cultivar, the estimation of SCA effects serves helpful information on both parental forms (maternal and paternal) used in the individual cross combination (Arsode et al. 2017). Unfortunately, in the present populations, most of the hybrids had non-significant SCA effects or significant, but in the undesired direction. Similarly, no single hybrid showed high and significant SCA effects for all traits. However, the significant and positive SCA effects were estimated for the following hybrid families: Caps 3 × Caps 5 (P2 × P3) for unhusked ear diameter, Caps 15 × Caps 23 (P4 × P8) and Caps 17B × Caps 22 (P6 × P7) for unhusked ear weight, Caps 5 × Caps 17B (P3 × P6) and Caps 17B × Caps 22 (P6 × P7) for husked ear length, Caps 2 × Caps 23 (P1 × P8), Caps 5 × Caps 17B (P3 × P6), Caps 15 × Caps 23 (P4 × P8), and Caps 17A × Caps 22 (P5 × P7) for kernel-row number, and Caps 2 × Caps 17A (P1 × P5), Caps 2 × Caps 17B (P1 × P6) and Caps 15 × Caps 23 (P4 × P8) for kernel number per row.

The importance of GCA and SCA effects can also be deducted from their relative contribution to the hybrid variation. The contribution of the GCA sum of square to the hybrid sum of square for total soluble solids content was the lowest (49%), while for other traits it ranged from 54% (for unhusked ear diameter) to 77% (for husked ear weight). The values of GCA : SCA ratio greater than one for all tested traits confirmed that GCA effects were more important than SCA effects, although the role of non-additive gene action was not negligible, either. In other words, the additive gene action was more preponderance in the inheritance of the studied ear traits, but non-additive genes played also a role in it. Similar findings were also reported by Dickert & Tracy (2002). Samad et al. (1989) suggested that selection of traits having high GCA effects, low SCA effects, and high GCA : SCA ratio should result in high genetic advance in hybrid progenies. Furthermore, the values of the general predictability ratio (GPR) close to unity for all tested traits were significant and indicated that the performance of the hybrid for the traits could be predicted from GCA alone (Baker 1978).

Although the genotype and environment interaction (G × E) was significant for some traits, the magnitudes of its effect were considerably lower than those of the corresponding main effects. Furthermore, the partitioning of G × E indicated that the interaction was mainly due to the inconsistencies in performance across environments among the parental inbred (P × E) and the difference between parental inbreds and hybrids (P-H × E). On the other hand, GCA × E and SCA × E interactions were non-significant for the tested ear traits, indicating that both genetic merits for the traits were preserved in the changing environmental conditions. The non-significance of GCA × E interaction for the studied traits also confirmed that selection on the GCA basis could be carried out in the breeding centers without performing unnecessarily extra efforts under different agro-ecological zones. By keeping all these findings in mind, Caps 17A, Caps 17B, Caps 5, and Caps 22 showed their potential usefulness as the parental inbreds in the sweet corn breeding programs for the development of new cultivars well suited under the organic crop management.

Table 5. GCA of the ear traits observed from eight sweet corn parental inbreds grown organically at three agro-ecological zones in the tropics

Parent	Unhusked ear			Husked ear			Kernel-row number	Kernel number per row	Total soluble solids content (°Brix)
	length (cm)	diameter (mm)	weight (g)	length (cm)	diameter (mm)	weight (g)			
Caps 2 (P1)	-0.4 ns	-1.3**	-0.6 ns	-0.7**	-1.0*	-22.7**	-1.2**	-1.9**	-0.3 ns
Caps 3 (P2)	-1.6**	-1.0*	-1.5**	-1.0**	-0.7 ns	-13.0**	-0.1 ns	-0.6 ns	0.2 ns
Caps 5 (P3)	-0.5 ns	1.3*	-0.1 ns	0.2 ns	1.8 ns	22.0**	0.0 ns	-0.6 ns	-0.1 ns
Caps 15 (P4)	-0.2 ns	-1.0*	-0.1 ns	1.0**	-0.6 ns	15.0**	0.8**	2.8**	0.7 ns
Caps 17A (P5)	1.3**	1.3*	1.3**	0.5**	1.0*	20.5**	0.7**	2.4**	-0.2 ns
Caps 17B (P6)	1.5**	0.4 ns	2.3**	0.7**	-0.6 ns	-6.5 ns	0.0 ns	-0.3 ns	0.1 ns
Caps 22 (P7)	-0.5 ns	1.1*	0.4 ns	-0.3*	0.7 ns	2.7 ns	0.0 ns	-0.3 ns	0.3 ns
Caps 23 (P8)	0.4 ns	-0.7 ns	-1.8**	-0.4**	-0.6 ns	-18.0**	-0.1 ns	-1.58**	-0.6 ns

*, ** statistically significant at 5% and 1 %, respectively, ns – non-significant

Table 6. SCA of the ear traits observed from twenty-eight sweet corn crosses grown organically at three agro-ecological zones in the tropics

Parent	Unhusked ear			Husked ear			Kernel-row number	Kernel number per row	Total soluble solids (°Brix)
	length (cm)	diameter (mm)	weight (g)	length (cm)	diameter (mm)	weight (g)			
P1 × P2	0.9 ns	0.1 ns	9.9 ns	0.2 ns	0.0 ns	-2.0 ns	-0.2 ns	-0.8 ns	-0.2 ns
P1 × P3	-0.4 ns	-1.2 ns	-20.0 ns	0.1 ns	0.3 ns	-4.4 ns	-0.8**	-1.6 ns	-0.3 ns
P1 × P4	0.4 ns	1.4 ns	11.2 ns	0.0 ns	1.3 ns	-4.1 ns	0.1 ns	-0.3 ns	0.4 ns
P1 × P5	0.4 ns	-0.1 ns	9.1 ns	0.6 ns	-1.4 ns	1.6 ns	0.2 ns	2.7*	-0.1 ns
P1 × P6	-0.7 ns	-0.5 ns	-1.4 ns	0.0 ns	0.4 ns	9.3 ns	-0.2 ns	2.6*	0.4 ns
P1 × P7	-1.1 ns	-0.3 ns	-21.0 ns	-0.7*	-0.9 ns	-4.1 ns	0.2 ns	-1.0 ns	-0.5 ns
P1 × P8	0.5 ns	0.5 ns	12.2 ns	-0.2 ns	0.4 ns	3.6 ns	0.6*	-1.6 ns	0.3 ns
P2 × P3	0.9 ns	3.0**	16.6 ns	-0.1 ns	1.2 ns	1.6 ns	0.2 ns	1.6 ns	0.0 ns
P2 × P4	-0.5 ns	-1.1 ns	-11.8 ns	-0.5 ns	-1.5 ns	-7.9 ns	0.1 ns	0.0 ns	0.4 ns
P2 × P5	-0.7 ns	-1.0 ns	-5.9 ns	-0.2 ns	-0.2 ns	1.5 ns	-0.3 ns	-0.7 ns	-0.1 ns
P2 × P6	-0.4 ns	0.9 ns	12.1 ns	0.5 ns	0.7 ns	15.9 ns	0.1 ns	1.0 ns	-0.7 ns
P2 × P7	-0.3 ns	-1.6 ns	-22.4 ns	-0.2 ns	0.3 ns	-12.1 ns	0.2 ns	-1.1 ns	0.3 ns
P2 × P8	0.2 ns	-0.4 ns	1.6 ns	0.3 ns	-0.5 ns	3.0 ns	-0.1 ns	0.0 ns	0.3 ns
P3 × P4	1.2 ns	-2.3*	-18.0 ns	-0.7*	-1.8 ns	-19.0 ns	-0.3 ns	-1.1 ns	-0.1 ns
P3 × P5	0.4 ns	2.2 ns	22.9 ns	0.4 ns	1.5 ns	13.2 ns	0.4 ns	0.9 ns	-0.4 ns
P3 × P6	-0.5 ns	0.3 ns	19.6 ns	0.7*	0.1 ns	14.0 ns	1.3**	0.4 ns	0.5 ns
P3 × P7	-1.2 ns	-0.7 ns	-3.6 ns	0.0 ns	0.3 ns	7.2 ns	-0.5 ns	-0.2 ns	0.0 ns
P3 × P8	-0.4 ns	-1.3 ns	-17.4 ns	-0.3 ns	-1.5 ns	-12.7 ns	-0.2 ns	0.0 ns	0.2 ns
P4 × P5	-0.9 ns	1.1 ns	1.0 ns	0.1 ns	1.0 ns	9.6 ns	0.3 ns	-0.9 ns	-0.6 ns
P4 × P6	-1.1 ns	-1.5 ns	-25.2 ns	-0.4 ns	-0.4 ns	-16.9 ns	-0.8**	-2.9**	0.6 ns
P4 × P7	0.3 ns	1.0 ns	6.6 ns	-0.4 ns	0.7 ns	7.1 ns	-0.1 ns	0.3 ns	-0.9*
P4 × P8	0.6 ns	1.4 ns	36.2*	1.9**	0.6 ns	31.2 ns	0.7*	4.9**	0.1 ns
P5 × P6	1.4 ns	-1.7 ns	-31.2*	-1.0**	-1.5 ns	-20.7 ns	-0.5 ns	-2.1 ns	0.0 ns
P5 × P7	0.4 ns	0.7 ns	14.6 ns	0.6 ns	1.0 ns	10.6 ns	0.6*	1.2 ns	0.5 ns
P5 × P8	-0.9 ns	-1.1 ns	-10.5 ns	-0.6 ns	-0.4 ns	-15.9 ns	-0.7*	-1.1 ns	0.7 ns
P6 × P7	1.6 ns	1.3 ns	36.9*	0.9**	-1.1 ns	-0.5 ns	0.1 ns	2.0 ns	0.6 ns
P6 × P8	-0.3 ns	1.2 ns	-10.8 ns	-0.7*	1.7 ns	-1.2 ns	0.1 ns	-1.0 ns	-1.4**
P7 × P8	0.4 ns	-0.4 ns	-11.2 ns	-0.3 ns	-0.3 ns	-8.2 ns	-0.5 ns	-1.2 ns	-0.1 ns

*, ** statistically significant at 5% and 1 %, respectively, ns – non-significant

CONCLUSION

The estimates of genetic parameters, including GCA, SCA, and the ratio of GCA : SCA confirm that the effect of additive gene action is more preponderance than the effect of non-additive gene action in the inheritance of the ear traits in sweet corn. The values of the general predictability ratio (GPR) suggest that the selection for the ear traits based on the GCA effects are worthwhile. Inbred lines: Caps 5, Caps 17A, Caps 17B, and Caps 22 are identified as the best potential parents in the development of new sweet corn cultivars well suited for organic production.

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