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Combining Ability for Twelve Characters in Baby Corn (*Zea mays* L.)

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Abstract

Baby corn is relatively new comparing to regular maize and the character of preference widely differs, therefore, it becomes essential to study various maize lines for combining ability and the nature of genes controlling various characters of baby corn. Since sweetness is one of the main criteria for selection of baby corn variety, six sweet corn lines were taken up for the study. From the the study of genetic components over environments it could be inferred that non-additive gene effect played the major role in the expression of the characters husked yield, dehusked yield, standard yield, ear length, ear diameter, breaking pressure, TSS, fodder yield and plant height. On the other hand, additive gene effect played important role in the expression of characters ear height and days to harvest. However, both additive and non-additive components played equal role in the expression of the character elasticity. From the sca and performance study crosses namely Hawaiian Sugar (Aul) × Sweet corn synthetic, Hawaiian Sugar (Au2) × Hawaiian-38, Hawaiian-38 × Sweet corn pool-2, Hawaiian Sugar (Au2) × Sweet corn synthetic and Hawaiian Sugar (Au2) × Sweet corn pool-1 were identified as the top five crosses considering the main desirable character standard yield with other associating characters. Parents Hawaiian Sugar (Au2) and Sweet corn synthetic were also identified as the best combiners for the character standard yield and other associating characters.
Key words : Baby corn, Sweet corn, Combining ability.

Combining ability refers to the capacity or ability of a genotype to transfer superior performance to its crosses. To employ a suitable breeding program, the knowledge of gene action is of immense value which varies depending upon the genetic variability and genetic divergence in the material used. Thus, the knowledge concerning the nature of gene action and their relative magnitude in conditioning the various attributes of importance is basic to the maximum efficiency of a breeding program. Moreover, the nature of genetic control of the characters of economic importance especially in the form of relative magnitudes of additive, dominance and interaction components is the determining factor to dictate the type of variety. Since, baby corn is relatively new comparing to regular maize and the character of preference widely differs, therefore, it becomes essential to study various maize lines for combining ability and the nature of gene controlling the various characters of baby corn. In our study, since sweetness is one of the main criteria for selection of baby corn variety, six sweet corn lines were taken up for the study.

Methods

Six sweet corn lines viz. Hawaiian Sugar (Aul), Hawaiian Sugar (Au2), Sweet corn synthetic, Hawaiian-38, Sweet corn pool-1 and Sweet corn pool-2; were grown during 2002-2003 *rabi*, at District seed Farm, Kalyani, with the spacing 75 × 25 cm, following standard cultivation practices. Lines were crossed in half diallel mating design to obtain the F_1s. A total of 15 cross combinations were obtained without reciprocals. For the study of the performance of materials developed by half- diallel, experiment was laid out in randomised block design with four replications. Fifteen hybrids along with six parents and a standard check VL-42, were put in trial separately in two environments (*kharif*, 2003 and *rabi*, 2003-04). Each plot consisted of double rows each of 5 m lengths. The row to row distance was 60 cm and plant to plant distance within row was 25 cm. Two rows of border

Table 1. ANOVA for combining ability for various characters of baby corn (sweet corn) pooled over (half diallel analysis). **, *, : Significant at 1% and 5% level of probability.

Source	df	Mean sum of square Husked yield	Dehusked yield	Standard yield	Ear length	Ear diameter	Breaking pressure
GCA	5	1449051.3**	23740.59**	40760.79**	1.6925**	0.0225**	71068.20**
SCA	15	596467.46**	27072.64**	18265.91**	0.8244**	0.01375**	21013.23**
Env	1	25573183**	416.922	6766.588	0.0054	0.000311	16598.59*
GCA × E	5	1555472.5**	3961.677	7426.394**	0.0266	0.000701	1813.692
SCA × E	15	417711.71**	4792.198	1936.405	0.0394	0.000690	1939.086
Error	120	77093.173	5011.643	2207.440	0.0503	0.000811	3647.717

Table 1. Continued.

Source	df	Mean sum of square Elasticity	TSS	Fodder yield	Plant hight	Ear height	Days to harvesting
GCA	5	47.3681**	0.05861	8541.177**	232.396**	479.643**	10.400**
SCA	15	12.1063**	0.32040**	3128.668**	220.458**	57.0181**	1.7666**
Env	1	0.00344	0.00151	6194.100**	113.331	2218.49**	9122.88**
GCA × E	5	5.20355	0.05132	820.264	35.0839	175.872**	5.3791**
SCA × E	15	1.25444	0.05607	529.821	45.1757	80.4058**	1.4148**
Error	120	2.59575	0.07560	611.777	49.1757	19.9520	0.4511

were given on both the sides of each block. Standard cultural practices were followed to raise a good crop.

Ten competitive plants were labelled in each plot in every replication for recording of data on plant height and ear height. Ear lengths, war diameters, TSS, ear breaking pressure, elasticity capacity of ear were recorded at harvest from ten ears selected at random in each plot. For yield, weight and number of cobs each plot were recorded and then yield in terms of kg per hectare was estimated. Griffing's (1956) method-2 (model 1) was followed for the analysis. The data generated from the field experiments were analyzed using SPARI software for various statistical parameters.

Results and Discussion

The analysis of variance for combining ability from the pooled environment (Table 1) revealed that all the characters showed significant mean sum of square for gca and sca except for the character TSS which showed significant mean sum of square for sca only, indicating the importance of both additive and non-additive gene action for controlling almost all characters. The effect of environment was significant for husked yield, breaking pressure, fodder yield, ear height and days to harvesting; gca × environment interactions were significant for husked yield, standard yield, ear height and days to harvest and sca × environment interactions were significant for husked yield, ear height and days to harvest. These indicate that there are influences of environment for the expression of these characters. Thus it is concluded that selection of parents and prediction of performance of hybrids should be emphasized on the consistent superiority of performance over environments for the characters which showed influence of environment.

The components of combining ability variances, i.e., σ^2 gca and σ^2 sca and of genetic variations i.e. additive genetic variances (σ^2A) and dominance variances (σ^2D) and their (σ^2A / σ^2D) for all the characters studied in pooled over environments are presented in Table 2.

The pooled data revealed that there was preponderance of dominance effect for all the characters except in ear height. The results in pooled environment revealed that, additive genetic component (σ^2A) was higher than dominance component (σ^2D) for ear height and days to harvest, while reverse results were observed for rest of the characters indicating the importance of non-additive gene action in the expression

Table 2. Estimates of variance components, genetic components and heritability for various character of baby corn (sweet corn) pooled over Environments (half diallel analysis). ϕ = negative value of σD^2 / σA^2 ratio.

Component	Husked yield	Dehusked yield	Standard yield	Ear lingth	Ear diameter	Breaking pressure	Elast	TSS	Fodder yield	Plant height	Ear height	Days to harvest
σg^2	53286.49	-208.2531	1405.93	0.0542	0.000547	3128.436	2.2038	-0.0163	338.28	0.7461	26.414	0.5395
σs^2	259687.14	11030.499	8029.235	0.3870	0.00647	8682.757	4.7552	0.1224	1258.4	85.641	18.533	0.6577
σl^2	1103066.1	-139.136	-227.49	-0.0005	-0.000019	708.521	-0.388	-0.0022	245.52	4.0664	93.858	434.02
σgl^2	246396.55	-174.9943	869.8256	-0.0039	-0.000018	-305.67	0.4346	-0.0040	34.747	-2.348	25.986	0.8213
σsl^2	340618.53	-219.445	-271.035	-0.0109	-0.00012	-1708.63	-1.341	-0.0195	-81.956	-4.000	6.453	0.9637
σe^2	77093.173	5011.643	2207.44	0.0503	0.00081	3647.72	2.595	0.0756	611.77	49.175	19.952	0.4511
σA^2	106572.98	-416.5063	2811.86	0.1085	0.001094	6256.871	4.407	-0.0327	676.56	1.492	52.828	1.0791
σD^2	259687.14	11030.499	8029.235	0.3870	0.00647	8682.757	4.7552	0.1224	1258.4	85.641	18.533	0.6577
σP^2	443353.29	15625.635	13048.53	0.5458	0.008374	18587.34	11.758	0.1652	2546.7	136.30	91.313	2.1880
σD^2/ σA^2	2.4367071	ϕ	2.855488	3.5668	5.914971	1.387715	1.078	ϕ	1.860	57.390	0.3508	0.6094
h^2 (narrow sense)	0.2403793	–	0.215492	0.1987	0.130609	0.33662	0.3748	–	0.2656	0.0109	0.5785	0.4932

of almost all characters except ear height and days to harvest.

It is revealed from the result of pooled environment that, over dominance type of gene action was important for husked yield, dehusked yield, standard yield, ear length, ear diameter, breaking pressure, TSS, fodder yield, plant height, and partial dominance was important for ear height and days to harvest, and both additive and non-additive component was of equal importance for elasticity.

Thus, from the study of genetic components over environments it could be inferred that, non-additive gene effect played the major role in the expression of the characters husked yield, dehusked yield, standard yield, ear length, ear diameter, breaking pressure, TSS, fodder yield and plant height. On the other hand, additive gene effect played important role in the expression of characters ear height and days to harvest. However, both additive and non-additive component played equal role in the expression of the character elasticity.

The results obtained by different workers with regard to the importance of gene action for the expression of various characters of baby corn are more or less contrary to the results of the present investigation. The importance of additive gene effect was reported by Viola et al. (2003) for ear length, TSS, ear yield per plant; Rodrigues et al. (2002) for number of ears per plant, ear length, ear diameter, ear weight, plant height and ear height, Verma and Sharma (2001) for ear yield; Tiwari and Verma (1999) for baby corn yield; and Fongmance et al. (1998) for ear yield of baby corn. On the other hand, preponderance of non-additive genetic component was reported by Nandy (2002) for ear length, ear diameter, TSS, breaking pressure, fodder yield and ear yield of baby corn . Moreover, the magnitude of σ^2 sca × environment interactions were observed to be greater than σ^2 gca × environment interaction for husked yield, ear height and days to harvest, indicating that the influence of environment on the non-additive component is higher than the influence of environment on the additive components for the expression of the characters, whereas σ^2 sca × environment interaction of other remaining characters showed negative values. This finding was in agreement with the observation of Rojas and Sprague (1952) who suggested that non-additive effects were influenced more by environment than additive effects. One disagreement result observed in this investigation was the negative estimates of some genetic variance components. Therefore, the ratios of additive/ dominance components were nor estimated. Negative estimate of dominance variance was recorded also by a number of workers (Robinson et al. 1955 Eberhart et al. 1966). The negative estimate of additive genetic variance was also reported by Williams et al. 1965.

Table 3. Best parents, best combiners, hest crosses, best specific crosses and best heterotic crosses in pooled over environments. Line code in crosses; 1 = Hawaiian Sugar (Aul); 2 = Hawaiian Sugar(Au2); 3 = Sweet corn synthetic; 4 = Hawaiian—38; 5 = Sweet corn pool-1 and 6 = Sweet corn pool-2. H= High, L = Low.

	Character	Best parents (*per se* performance)	Best combiners (gca effect)	Best crosses (*per se* performance
1	Husked yield (kg/ha)	1. Hawaiian Sugar (Aul) (4983.30) 6. Sweet corn pool-2 (4270.93) 2. Hawaiian Sugar (Au2) (3684.44) 3. Sweet corn synthetic (3324.89)	1 Hawaiian Sugar (Aul) (468.37)	1 × 3 (5037.09) 2 × 5 (4896.43) 1 × 5 (4606.27) 3 × 6 (4326.09) 2 × 3 (4286.48) 3 × 4 (4252.93)
2	Dehusked yield (kg/ha)	2. Hawaiian Sugar (Au2) (846.36) 6. Sweet corn pool-2 (824.06) 4. Hawaiian-38 (792.53) 1. Hawaiian Sugar (Aul) (757.01)	1. Hawaiian Sugar (Aul) (50.88)	1 × 3 (1158.81) 1 × 4 (1007.26) 2 × 3 (957.35) 2 × 5 (910.03) 1 × 5 (894.83)
3	Standard yield (kg/ha)	2. Hawaiian Sugar (Au2) (338.54) 6. Sweet corn pool-2 (329.62) 4. Hawaiian-38 (317.01) 1. Hawaiian Sugar (Aul) (303.00)	2. Hawaiian Sugar (Au2) (71.93) 3. Sweet corn synthetic (35.75)	1 × 3 (521.46) 2 × 4 (511.30) 4 × 6 (479.42) 1 × 4 (453.26) 2 × 3 (430.80) 2 × 5 (409.51)
4	Ear Length (cm)	2. Hawaiian Sugar (Au2) (9.72) 1. Hawaiian Sugar (Aul) (9.34) 6. Sweet corn pool-2 (9.18)	1. Hawaiian Sugar (Aul) (0.43) 2. Hawaiian Sugar (Au2) (0.19) 6. Sweet corn pool-2 (0.19)	1 × 6 (10.53) 2 × 3 (9.80) 1 × 3 (9.58) 1 × 5 (9.55) 1 × 4 (9.49) 4 × 6 (9.42) 3 × 4 (9.30)
5	Ear diameter (cm)	6. Sweet corn pool-2 (1.44) 1. Hawaiian Sugur (Aul) (1.39) 2. Hawaiian Sugur (Au2) (1.34)	6. Sweet corn pool-2 (0.07)	4 × 6 (1.44) 3 × 6 (1.41) 2 × 3 (1.36) 2 × 5 (1.36) 1 × 4 (1.34)
6	Breaking pressure (gm / unit area)	1. Hawaiian Sugar (Aul) (681.70) 3. Sweet corn synthetic (820.31) 4. Hawaiian-38 (974.48)	1. Hawaiian Sugur (Aul) (–69.78) 3. Sewwt corn synthetic (–52.43)	1 × 3 (805.20) 3 × 4 (853.89) 4 × 5 (865.04) 2 × 4 (961.45) 2 × 6 (1030.84)
7	Elasticity (°)	4. Hawaiian-38 (35.00) 5 Sweet corn pool-1 (30.88) 2. Hawaiian Sugar (Au2) (30.25)	4. Hawaiian-38 (2.79) 2. Hawaiian Sugar (Au2) (0.87)	2 × 4 (34.00) 3 × 4 (34.00) 1 × 6 (30.94) 1 × 4 (30.62) 2 × 5 (30.62)
8	TSS (%)	1. Hawaiian Sugar (Aul) (14.18) 5. Sweet corn corn pool-1 (13.44) 6. Sewwt corn pool-2 (13.37)	1. Hawaiian Sugar (Aul) (0.11)	2 × 5 (13.76) 4 × 6 (13.62) 3 × 4 (13.57) 1 × 4 (13.52) 4 × 5 (13.45) 2 × 6 (13.38) 1 × 3 (13.36) 5 × 6 (13.33)
9	Fodder yield (q/ha)	1. Hawaiian Sugar (Aul) (421.27) 5. Sweet corn pool-1 (383.36) 4. Hawaiian-38 (344.01)	1. Hawaiian Sugar (Aul) (27.09) 5. Sweet corn pool-1 (16.19)	1 × 5 (464.68) 1 × 4 (445.56) 3 × 4 (425.78) 2 × 4 (362.20)

Table 3. Continued.

	Character	Best parents (*per se* performance)	Best combiners (gca effect)	Best crosses (*per se* effect)
			4. Hawaiian-38 (14.30)	
10	Plant height (cm)	3. Sweet corn synthetic (214.38) 2. Hawaiian Sugar (Au2) (218.00) 6. Sweet corn pool-2 (218.12)	6. Sweet corn pool-2 (–4.65)	1 × 6 (201.36) 2 × 5 (215.99) 4 × 5 (217.96) 2 × 3 (218.08)
11	Ear height (cm)	6. Sweet corn pool-2 (78.67) 5. Sweet corn pool-1 (83.11) 4. Hawaiian-38 (84.24)	5. Sweet corn pool-1 (–3.77) 4. Hawaiian-38 (–3.33) 6. Sweet corn pool-2 (–3.08)	4 × 5 (72.80) 2 × 4 (81.41) 3 × 5 (85.40) 3 × 6 (87.00)
12	Days to harvest	5. Sweet corn pool-1 (69.50) 6. Sweet corn pool-2 (71.50) 4. Hawaiian-38 (71.75)	5. Sweet corn pool-1 (–1.28) 4. Hawaiian-38 (–0.41)	2 × 4 (70.50) 2 × 5 (70.50) 3 × 4 (70.50) 3 × 5 (70.75) 4 × 5 (71.00)

Table 3. Continued.

	Character	Best specific crosses (sca effect)	Best heterotic crosses	Best common crosses	Genetic interac-tion
1	Husked yield (kg/ha)	2 × 5 (1020.59) 3 × 4 (669.62) 1 × 3 (519.34)	1 × 3 2 × 5 3 × 4 2 × 3	1 × 3 2 × 5 3 × 4 2 × 3	H × L L × L L × L L × L
2	Dehusked yield (kg/ha)	1 × 3 (247.79) 1 × 4 (141.57) 2 × 5 (115.36)	1 × 3 1 × 4 1 × 5 2 × 5 2 × 3	1 × 3 1 × 4 2 × 5 2 × 3 1 × 5	H × L H × L L × L L × L H × L
3	Standard yield (kg/ha)	4 × 6 (141.42) 2 × 4 (141.08) 2 × 3 (72.80) 1 × 2 (65.71) 2 × 5 (61.91)	1 × 3 2 × 4 4 × 6 1 × 4 1 × 5 2 × 5	1 × 3 2 × 4 4 × 6 2 × 3 2 × 5	L × H H × L L × L H × H H × L
4	Ear Length (cm)	1 × 6 (0.85) 2 × 3 (0.68) 3 × 4 (0.66) 2 × 5 (0.60) 1 × 5 (0.48) 4 × 6 (0.46) 1 × 4 0.29)	1 × 6 2 × 3 1 × 3 1 × 5 1 × 4 4 × 6 3 × 4 2 × 5	1 × 6 2 × 3 1 × 5 4 × 6 1 × 4 3 × 4 1 × 3 2 × 5	H × H H × L H × L L × H H × L L × L H × L
5	Ear diameter (cm)	2 × 5 (0.10) 4 × 6 (0.09) 2 × 3 (0.06) 1 × 4 (0.06) 3 × 6 (0.04) 4 × 5 (0.04)	4 × 6 3 × 6 2 × 5	4 × 6 3 × 6 2 × 5 2 × 3 1 × 4	L × H L × H L × L L × L L × L
6	Breaking pressure	2 × 4 (-111.58)	–	2 × 4	L × L

Table 3. Continued.

	Character	Best specific crosses (sca effect)	Best heterotic crosses	Best common crosses	Genetic interaction
	(gm/unit area)	2 × 6 (-101.11)		2 × 6	L × L
		4 × 5 (-81.42)		1 × 3	H × H
				4 × 5	L × L
7	Elasticity (°)	3 × 4 (4.27)	3 × 4	2 × 4	H × H
		2 × 3 (2.44)	2 × 4	3 × 4	L × H
		1 × 6 (2.32)		1 × 6	L × L
				1 × 4	L × H
				2 × 5	H × L
8	TSS (%)	2 × 5 (0.47)	2 × 5	2 × 5	L × L
		4 × 6 (0.41)	4 × 6	4 × 6	L × L
		3 × 4 (0.38)	3 × 4	3 × 4	L × L
			1 × 4	1 × 4	H × L
			4 × 5	4 × 5	L × L
			2 × 6	2 × 6	L × L
			1 × 3	1 × 3	H × L
			5 × 6	5 × 6	L × L
9	Fodder Yield (q/ha)	1 × 5 (60.73)	1 × 5	1 × 5	H × H
		3 × 4 (56.62)	1 × 4	1 × 4	H × H
		1 × 4 (43.49)	3 × 4	3 × 4	L × H
		2 × 6 (32.95)			
10	Plant height (cm)	1 × 6 (–25.41)	1 × 6	1 × 6	L × H
		4 × 5 (–8.70)		4 × 5	L × L
				2 × 5	L × L
				2 × 3	L × L
11	Ear height (cm)	4 × 5 (–10.70	4 × 5	4 × 5	H × H
		2 × 4 (–6.30)		2 × 4	L × H
				3 × 5	L × L
				3 × 6	L × L
12	Days to harvest	2 × 4 (–1.88)	2 × 4	2 × 4	L × H
		2 × 5 (–1.00)	2 ×5	2 × 5	L × H
			3 × 4	3 × 4	L × H
			3 × 5	3 × 5	L × H
			4 × 5	4 × 5	H × H
			5 × 6		

Considering characters like ear height or days to harvest, breeding program like mass selection or recurrent selection for general combining ability which makes good utilization of additive genetic variance available in the material, will be useful and may opt for the development of synthetic and composite varieties. But, for the improvement of elasticity the breeding methods like reciprocal recurrent selection capitalizing both additive and dominance variance can be suggested as effective breeding strategy for development of baby corn populations.

In the present investigation, from the estimate of general combining ability effects pooled over environments, the best combiners for different characters are presented in Table 3. The specific combining ability effects of 15 cross combinations were estimated for 12 characters in two environments and pooled over environment.

Top ranking hybrids for standard yield with other associated characters were identified on the basis of high mean performance, high heterotic response, high sca effect involving mostly one good combiner.

In the present investigation, the following five top ranking hybrids were identified on the basis of high heterotic response, high sca effects high mean performance and good combiner for a good number of characters : Hawaiian Sugar (Au1) × Sweet corn synthetic (1 × 3) was the best one for standard yield with other associated characters viz. husked yield, dehusked yield, ear length, breaking pressure and

TSS. Hawaiian Sugar (Au2) × Hawaiian-38 (2 × 4) was placed among the best hybrids for standard yield with other associated characters viz. breaking pressure, elasticity, fodder yield, ear height and days to harvest. Hawaiian-38 × Sweet corn pool-2 (4 × 6) ranked highest among the best hybrids for standard yield and other associated characters viz. ear Length, ear diameter and TSS. Hawaiian Sugar (Au2) × Sweet corn synthetic (2 × 3) was placed in the top of the list of the best hybrids for standard yield with other associated characters viz. husked yield, dehusked yield, ear length, ear diameter and plant height. Hawaiian Sugar (Au2) × Sweet pool-1 (2 × 5) placed as top ranking hybrid for standard yield with other associated characters viz. dehusked yield, ear diameter, TSS, plant height and days to harvest.

In the present investigation, none of the hybrids showed highest performance in all the parameters for all the characters studied. Hence, the selection of top ranking hybrids of baby corn on the basis of high heterotic response, high sca effects, high mean performance along with other related parameters for a good number of characters accommodated essentially emphasizing marketable yield for baby corn is suggested.

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