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Studies on Baby Corn (Zea *mays* L.) genotypes for their combining ability and heterosis based on Pre and post harvest traits

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ABSTRACT

The experiments were conducted to find out the suitable genotypes developed by crossing divergent inbreed line for baby corn. The crosses were evaluated on the basis of pre and post harvest traits for GCA effect, SCA effect and heterosis over better parents. For this, the eight genetically diverse baby corn inbreds were crossed in diallel mating design following Model-I, Method-II of Griffing (1956) during rabi 2013-14 and evaluated in kharif 2014-15. Variance due to GCA and SCA were highly significant, indicating both additive and non additive types of gene action are important for controlling the traits. Predominance of non-additive gene action was observed for all the pre and post harvest traits. The range of heterosis over better parent for important pre harvest traits such as number of cob per plant is 1.34 to 23.30 and for cob diameter -45.27 to 53.92 respectively. Similarly, for post harvest trait it was ranged from 7.06 to 66.58 % for baby corn yield and for fodder yield from 12.28 to 74.24%. It was found that parent VQL-1 was the best combiner for baby corn yield coupled with number of baby corn per plant and parent DTPYC was the best combiner showing significant positive gca effect for fodder yield .The cross combinations CM128× VQL1 possessed significant desirable sca effects and high heterosis both for pre and post harvesr traits which might be used for obtaining high yielding quality hybrids.

***Keywords**: Baby corn, genotype, Morphological and Nutritional quality traits*

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INTRODUCTION

Maize has been cultivated for centuries as a grain crop and more recently it becoming very popular as vegetables, such as baby corn (*Zea mays* var. *saccharata*) (Mahajan *et al.,* 2007). Baby corn is very delicious, decorative and nutritious vegetable rich in fibrous protein which is easy to digest and low calorific vegetable. It is grown for its young, fresh, finger like green ears, harvested at the time of silk emergence and before pollination and fertilization (Ramachandrappa *et. al*., 2004). Baby corn is the earliest stage, as the product is harvested just 2-3 days after silk emergence in the form of tender unfertilized ears. It is very delicious, decorative and nutritious vegetable rich in fibrous protein which is easy to digest and low calorific vegetable. It is also uniquely suited for value-addition and preparation of several recipes (Dass *et al*., 2008). There is also a great potential to earn foreign exchange through export of fresh/canned baby corn as well as its processed products.

India is emerging as one of the potential baby corn producing countries. Among the Indian states, Rajasthan is first in respect of area, where this crop occupies area, production and productivity 10.5 lakh ha, 19.5 lakh tones, 18.6 q ha^{-1}respectively (Government of Rajasthan, 2010).

The production areas of baby corn (*Zea mays* L.) are still confined to a few countries, including Thailand, Indonesia, India, and Brazil. Baby corn production and improvement on the part of the breeders has resulted in the development of number of varieties. Even though, there was no much works had been done (Chauhan *et. al.,* 2010).

Detailed information is scarce regarding quality aspects of these genotypes in national and international marketing. Hence, the present investigations were undertaken to assess various morphological traits relevant for baby corn usage so as to identify elite hybrids as per consumer preference.

MATERIALS AND METHODS

Experimental material

The present experiment was carried out at BAC Farm of Bihar Agricultural University, Sabour, Bhagalpur (Bihar), during *rabi* 2013-14 and *kharif* 2014. The eight genetically diverse baby corn inbreds viz., HKI 3209, SML 1, EC 595979, CM 128, VQL 1, G 18 seq C5 F76-2-2-1-1-2-BBB, HKI 209, were crossed in diallel mating design following Model-I, Method-II of Griffing (1956) during *rabi* 2013-14 (Table 1).

Experimental methods

The parents and their resulting 28 F_1s were raised in a Randomized Complete Block Design (RCBD) with 3 replications during *kharif* 2014. Each plot consisted 2 rows of each 5 m in length and spacing between rows and plants were 60 cm and 20 cm, respectively. Two seed per hill were planted to ensure the optimum population and recommended package of practices were followed to raise a healthy crop (Crop production guide, 2012).

The observations were recorded on 10 randomly selected plants and 20 numbers of baby corn of each genotype in each replication for nine morphological traits (baby corn per plant, cob length, cob diameter, cob weight, baby corn length, baby corn diameter, baby corn diameter, baby corn yield and fodder yield) as these traits are used in determining the morphological quality of baby corn. The variability was estimated in terms of range, standard error and mean values.

RESULTS AND DISCUSSION

The analysis of variance for genotypes and combining ability (GCA and SCA) are presented in Table 2. Genotypes differed significantly for all the pre harvest and post harvest traits, indicating sufficient genetic variability present among them.

Analysis of variance for combining ability revealed that estimates of mean squares due to GCA and sca were highly significant for all the pre harvest and post harvest traits, indicating these traits are governed by both additive and non-additive gene action. The result agreed with those of Debnath and Sarker [1990] in normal maize and Verma and Narayan [2008] in QPM maize.

In the present study, the magnitude of sca variance was higher than gca for all the studied parameters, indicating the importance of non-additive gene action (dominance and epistasis) in the inheritance of the traits. The result is in close agreement with Bhatnagar *et al*. [2004], who reported the importance of both additive and non-additive genetic variances in QPM maize and found greater magnitude of sca variance than gca in their study. The predominance of non-additive gene action for yield-related and quality characters was also reported by Hossain and Prasanna [2008] in QPM maize. In a study Hallauer and Miranda Filho [1988] reported that non-additive gene effects seem to be small, but they may be important for specific combinations.

General Combining Ability (GCA) Effects: The estimates of GCA effects of the parents for different characters are presented in Table 3. A wide range of variability for gca effects was observed among the parents for different characters. The GCA effects are important indicators of the value of inbreds in hybrid combinations.

It was observed from the GCA effects that, the parent VQL-1 was best combiner for trait baby corn yield (1.16q/ha) and also performs significantly well for other quality traits such as days to 50 percent tasseling (-0.04), days to 50 percent silking (-0.26) and number of baby corn per plant (0.31). The parent CM 128 was second best combiner for baby corn yield parameter (0.27q/ha). Beside this, parent CM128 also having good combining ability for fodder yield (6.76 q/ha), cob diameter (0.04 cm) and baby corn per plant (0.12). The significant GCA effect for fodder yield was observed highest (10.23) in DTPYC followed by (6.76) in CM 128. None of the parents individually showed good general combiner for all the characters. Among the parents, VQL-1 and CM 128 had desirable significant GCA effects for yield.

Specific Combining Ability (SCA) Effects: The estimates of SCA effects of the baby corn crosses are presented in Table 4. The cross CM128 X VQL-1 was best specific combiner for baby corn yield (4.41 q/ha) followed by VQL-1 X HKI 209 (3.37q/ha). The lowest specific combining ability for baby corn yield was observed in the cross SML-1 X VQL-1 (-1.50 q/ha) In case of post harvest parameters, the cross CM128 X VQL-1 was best specific combiner for baby corn yield (4.41 q/ha) and fodder yield (50.91q/ha) also. Overall, for both pre harvest and post harvest traits, the parent CM128 and VQL-1 was best specific combiner followed by parents VQL-1 and HKI 209.

The results showed that, generally gca effects of the parents did not reflected in their sca effect for all the traits which is reported by Ivy and Howlader [2000]. Moreover, Amiruzzaman et al., [2011] also pointed out that the sca is a result of the interaction of gca effects of the parents and that it can improve or deteriorate the hybrid expression compared to the expected effect based on gca only. The sca effects of the crosses did not show any specific trends in cross combinations between parents possessing high, medium and low gca. In most of the cases, the crosses those showed high sca effects involved at least one good combiner. Aguiar et al. [2003] also pointed out similar opoinon that in the diallel analyses, one must select hybrids of highest specific combining ability in which one of the parental lines presents highest general combining ability.

Heterosis

The percent heterobeltiosis expressed by F1 for different characters is presented in table 5. The level of heterosis varied widely among the crosses. Most of the crosses showed significantly positive heterosis for baby corn yield and fodder yield. However, the crosses CM128 x VQL1 exhibited significant positive heterosis for all the pre and post harvest traits. .

Among the 28 crosses, the cross HKI 3209x EC595979 having significantly highest level of heterosis (66.58%) for baby corn yield. Likely, for fodder yield, the cross CM 128xHKI 209 (74.24%) performed best over the check VQL -1.

The range of heterosis for baby corn yield was 7.06 to 66.58%. In this study, the highest heterosis reached only upto 66.58% over the commercial check. The lowest heterosis (7.06%) was observed in SML-1 X HKI-209 which lowest heterosis of this cross might be due to both of the parents SML-1 and HKI-209. Based on the results, it is observed that only a single cross CM 128 X VQL-1 possed high baby corn as well as fodder yield and its contributing traits.

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Table 1: List of Parental lines and its sources.

S.N.	Name of the parents	Sources
1	HKI 3209	KARNAL, HISAR
2	SML 1	BAU, SABOUR
3	EC 595979	CIMMYT, MEXICO
4	CM 128	DMR, NEW DELHI
5	VQL 1	ALMORA , UTTRAKHAND
6	G 18 seq C5 F76-2-2-1-1-2-BBB	CIMMYT, MEXICO
7	HKI 209	KARNAL, HISAR
8	DTPYC-F38-5-2-1-1-2-2-1-B4	CIMMYT, MEXICO

Table 2: ANOVA for combining ability and estimates of variance component in diallel

		Mean sum of squares							
Source	**df**	**Tasseling (50%) Days**	**Silking (50%) Days**	**Baby corn/ Plant (No.)**	**Cob diameter (cm)**	**Baby corn length (cm)**	**Baby corn diameter (cm)**	**Baby corn yield (q/ha)**	**Fodder yield (q/ha)**
GCA	**7**	1893.02**	2181.96**	6.68**	2.65**	55.43**	1.16**	179.39**	66252.99**
SCA	**28**	4608.48**	5303.61**	17.27**	6.34**	127.32**	2.75**	447.15**	187673.88**
Error	**14**	0.30	0.32	0.00	0.01	0.12	0.00	0.39	767.12
		Estimate of variance component							
σ^2**gca**		271.55	312.16	1.06	0.37	7.19	0.16	26.78	12142.09
σ^2**sca**		4608.18	5303.29	17.27	6.33	127.20	2.75	446.76	186906.75
σ^2**e**		0.30	0.32	0.00	0.01	0.12	0.00	0.39	767.12
σ^2**gca/**σ^2**sca**		-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.07

Table 3: GCA effects of parents for pre & post harvest traits

Parents	Tasseling (50%)Days	Silking (50%) Days	Baby corn/ Plant (No.)	Cob diameter (cm)	Baby corn yield (q/ha)	Fodder yield (q/ha)
HKI 3209	-0.21	-0.03	-0.09**	-0.05	-0.25	**-13.44**
SML – 1	0.96**	0.97**	-0.04**	-0.02	0.18	-6.17
EC 595979	-0.18	-0.23	0.12**	-0.06*	-0.33	-5.84
CM 128	0.36*	0.08	0.12**	0.04	0.27	6.76
VQL – 1	-0.04	-0.26	0.31**	-0.07*	**1.16****	-1.01
G 18	-0.14	0.11	--0.18**	0.03	-0.17	4.49
HKI 209	-0.38*	-0.19	-0.27**	0.16**	**-0.53****	4.99
DTPYC	-0.38*	-0.46**	0.02	-0.14**	-0.33	**10.23**
SE(gi)±	0.16	0.16	0.01	0.02	**0.18**	8.19
SE(gi-gj) ±	0.24	0.25	0.01	0.02	0.27	12.38
CD at 5%	0.32	0.33	0.02	0.05	0.36	16.33
CD at 1%	0.42	0.44	0.02	0.07	0.48	21.68

***,** = significant at P=0.05 and P= 0.01, respectively.**

Table 4: SCA effects of crosses for Pre & post observation

Crosses	Tasseling (50%) Days	Silking (50%) Days	Cob / Plant(No.)	Cob diameter (cm)	Baby corn yield (q/ha)	Fodder yield (q/ha)
HKI 3209 x SML1		-0.90*	-0.38**	0.05	-0.42	21.27
HKI 3209 x EC 5	-0.26	-0.70	0.46**	-0.87**	2.72**	10.94
HKI3209 x CM 12	1.21**	0.33	-0.58**	0.06	-0.17	31.01

HKI 3209 xVQ 1	-0.39	-0.67	1.20**	-0.25**	2.71**	16.77
HKI 3209 x G 18	-1.62**	-0.70	-0.31**	0.05	0.94*	28.61
HKI 3209 x HKI 2	-0.06	0.60	-0.16**	-0.11	0.36	36.77
HKI 3209 x DTPY	-0.72	-0.80	0.56**	-0.05	1.28**	4.21
SML 1 x EC 5959	__1.24**__	1.63**	0.44**	__-0.95**__	-0.09	38.34
SML 1 x CM 128	0.04	0.00	__1.41**__	-0.06	3.08**	21.74
SML 1 x VQL1	0.78	0.66	-0.75**	-0.04	__-1.50**__	8.17
SML 1 x G 18	-0.46	0.30	0.74**	0.17*	2.01**	29.34
SML 1 x HKI 209	0.11	-0.40	-0.20**	0.06	0.04	34.17
SML 1 x DTPYC	-0.22	-0.14	-0.42**	-0.01	0.00	40.27
EC 595979 x CM 1	__-1.82**__	__-1.47**__	-0.82**	-0.15	1.01*	17.07
EC 595979 x VQL	-0.09	-0.47	-__0.98**__	0.04	-1.01*	34.51
EC 595979 x G 18	0.68	-0.50	-0.52**	0.09	1.28**	1.34
EC 595979 x HKI	-0.09	-0.20	0.63**	0.02	1.65**	26.84
EC 595979 x DTP	0.91*	0.73	0.28**	0.01	1.39**	12.27
CM 128 xVQL 1	-0.96*	-1.10*	0.05	0.29**	__4.41**__	__50.91*__
CM 128 x G 18	-0.52	1.20**	-0.52**	-0.01	-0.43	33.74
CM 128 x HKI 20	1.04	1.50**	-0.37**	-0.02	-0.35	29.91
CM 128 x DTPYC	1.04	__1.76**__	0.35**	0.02	-0.24	20.67
VQL 1 x G 18	0.21	-0.14	0.35**	-0.08	1.14*	30.84
VQL 1 x HKI 209	1.11	1.50**	0.44**	0.03	3.37**	14.34
VQL 1 x DTPYC	-0.22	-0.24	0.09**	0.03	-0.03	**-24.23**
G 18 x HKI 209	-0.46	0.46	-0.07*	0.05	-0.54	25.51
G 18 x DTPYC	0.88*	1.06*	0.68**	0.11	2.20**	35.27
HKI 209 x DTPYC	-0.56	-0.97*	-0.33**	**0.31**	1.31**	37.11
SE(Sij)±	0.43	0.44	0.03	0.08	0.49	21.85
SE(Sij-Sik) ±	0.73	0.75	0.05	0.13	0.83	37.16
SE(Sij-Skl) ±	0.69	0.71	0.05	0.12	0.79	35.03
CD at 5%	0.86	0.88	0.06	0.15	0.98	43.56
CD at 1%	1.14	1.17	0.07	0.20	1.30	57.83

***, ** Maximum and minimum value respectively**

Table 5: Heterosis (%) over Better Parent (BP) for pre and post harvest morphological traits

Crosses	**Tasseling (50%) Days**	**Silking (50%) Days**	**Cob / Plant(No.)**	**Cob diameter (cm)**	**Baby corn yield (q/ha)**	**Fodder yield (q/ha)**
HKI 3209 x SML 1	-6.38**	-2.68	7.57	13.74	5.66	63.27
HKI 3209 x EC 595979	-4.32	-4.70	22.30*	6.76	66.58	40.51
HKI3209 x CM 128	0.00	-2.01	13.60	-5.19	27.82	64.39
HKI 3209 xVQL 1	-4.32	-4.70	-9.61	-45.27**	44.56	35.47
HKI 3209 x G 18	-7.19	-4.03	12.00	-5.41	49.27	56.70
HKI 3209 x HKI 209	-4.32	-2.01	10.95	7.55	36.97	69.88
HKI 3209 x DTPYC	-5.76	__-5.37**__	-1.86	-29.73	46.37	19.46
SML 1 x EC 595979	0.00	2.01	8.82	-2.90	7.65	59.49
SML 1 x CM 128	-1.42	-0.67	2.50	-9.42	37.68	63.26
SML 1 x VQL 1	-0.71	0.00	2.00	-7.69	8.26	34.80
SML 1 x G 18	-3.55	0.00	15.14	11.48	25.62	61.10
SML 1 x HKI 209	-2.84	-2.01	8.26	17.65	7.06	72.59
SML 1 x DTPYC	-3.55	-2.01	19.49	8.45	8.34	38.92
EC 595979 x CM 128	-5.11	-3.45	-10.01**	-25.32	38.16	54.93
EC 595979 x VQL 1	0.00	-2.07	0.59	1.74	12.90	48.31
EC 595979 x G 18	0.00	-1.38	11.82	16.78	51.88	45.07
EC 595979 x HKI 209	0.00	-1.38	13.82	21.60	49.37	59.31
EC 595979 x DTPYC	__2.26*__	0.00	12.39	-2.17	52.11	26.50
CM 128 xVQL 1	-2.92	-2.08	8.35	32.47	63.10	63.01
CM 128 x G 18	-2.19	4.20	-2.50	3.03	26.13	70.64
CM 128 x HKI 209	0.73	__4.93*__	7.62	-13.85	23.50	74.24

CM 128 x DTPYC	0.73	**4.93***	1.34	8.23	26.38	35.93
VQL 1 xG 18	-0.74	0.00	-3.04	-2.05	32.13	51.69
VQL 1 xHKI 209	2.24	**2.78**	2.55	39.02	39.46	43.58
VQL 1 x DTPYC	-0.75	-1.39	-2.21	11.46	21.06	12.28
G 18 x HKI 209	-2.94	2.10	6.85	53.92*	39.51	65.14
G 18 xDTPYC	0.00	2.80	11.71	-2.17	56.43	41.47
HKI 209 x DTPYC	0.00	0.00	2.77	39.32	43.87	42.51
CD at 5%	1.53	1.58	1.75	5.27	1.7519	78.13
CD at 1%	2.04	2.10	2.32	7.00	2.3248	103.68

***, ** Maximum and minimum value respectively**

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