Indian J. Genet., 74(3): 387-391 (2014)
DOI: 10.5958/0975-6906.2014.00859.1

Short Communication

Analysis of combining ability in experimental hybrids of Sweet corn (*Zea mays* var. *saccharata*)

K. Elayaraja[1]*, R. N. Gadag, Jyoti Kumari[1], Avinash Singode[2] and Dharam Paul[2]

Division of Genetics, Indian Agricultural Research Institute; [1]National Bureau of Plant Genetic Resources; [2]Directorate of Maize Research, Pusa Campus, New Delhi 110 012

(Received: December 2013; Revised: May 2014; Accepted: May 2014)

Abstract

The GCA and SCA variance in combining ability analysis among the crosses involving 11 sweet corn inbreds was significant for all the traits studied. The additive and non-additive gene effects were found predominant for all the traits. Inbred lines IPSA-8761, IPSA-8761, IPSA-8752, IPSA-8757 and IPSA-8754 were identified as good general combiners for different traits. Specific crosses namely, IPSA-8753 x IPSA-8755, IPSA-8753 x IPSA-8761, IPSA-8754 x IPSA-8758 and IPSA-8756 x IPSA-8758 had significant SCA effects and were identified for various flowering and maturity traits whereas IPSA-8755X IPSA-8758 and IPSA-8754X IPSA-8757 showed significant SCA effect for ear weight with husk, without husk and sugar content. The hybrid IPSA-8753 x IPSA-8759 also showed significant SCA effect for the main sweet corn traits referring to green ear weight without husk and sugar content. These findings could serve as crucial inputs required for improvement of sweet corn.

Key words: Sweet corn, sweetness, diallel, sca and gca variance, quality traits

Maize, being multi-utility crop, is unique among the cereals with >3500 different uses. Based on the grain composition different types such as dent, flint, pop, pod, waxy and floury maize are suitable for specific usages [1]. Sweet corn has higher sweetness than other types, especially at immature stage on account of different proportions of sugar as well as starch and in principle it is harvested 18-22 days after pollination. Most of the classical cultivars posses s*u* allele located on chromosome number 4, leading to accumulation of sugar and soluble polysaccharides in seed endosperm. The kernels of such sweet corn cultivars at maturity are translucent and more or less creased. Among many mutants, *su*, *sh2* alone or in combination with *se* are commercially exploited in sweet corn cultivars [2].

Sweet corn is very profitable to peri-urban farmers, as the crop is harvested early and fetch good price in the market, and the green stalk can be used as fodder. The major constraint is the limited availability of improved hybrids in general and under the public domain in particular [3]. Hence, there is a great need to develop good quality sweet corn hybrids. Besides yield, sugar content, green ear yield and total soluble solids (TSS) are the specific quality traits to be considered in sweet corn improvement. Most of these traits are quantitative in nature influenced by environment and show complex inheritance [4]. The present study was undertaken to determine genetic nature and inheritance of ear yield and quality parameters in sweet corn genotypes.

The material comprised of 11 inbred lines namely, IPSA-8751 (P1), IPSA-8752 (P2), IPSA-8753 (P3), IPSA-8754 (P4), IPSA-8755 (P5), IPSA-8756 (P6), IPSA-8757 (P7), IPSA-8758 (P8), IPSA-8759 (P9), IPSA-8760 (P10) and IPSA-8761 (P11). They were crossed in half diallel design at Agricultural Research

*Corresponding author's e-mail: elayarajagenetics@gmail.com
Published by the Indian Society of Genetics & Plant Breeding, F2, First Floor, NASC Complex, PB#11312, IARI, New Delhi 110 012
Online management by indianjournals.com

Station, ANGARU, Rajendranagar, Hyderabad during *rabi* 2008-09 generating a total 55 F_1s. The hybrids and parents along with two checks *viz*., Madhuri and Priya were evaluated in Randomized Block Design at IARI Experimental Farm, New Delhi during *kharif* 2009. Each experimental plot consisted of two rows, each of 5m length with 75 cm inter row and 20 cm plant-to-plant spacing following standard crop management and agronomic practices. The observations were recorded on days to 50% tasseling and silking, days to 75% maturity (on the basis of dry husk), plant height, ear placement height, green ear weight with and without husk, dehusked ear length, breadth, number of rows and kernels per ear, total soluble solids, and grain yield per plant, hundred grain weight and total sugar.

Data on ear weight, ear length, ear breadth, number of rows and kernels per ear were recorded at fresh harvest stage, that is, 20-22 days after pollination from the selfed ears as the average of five randomly selected dehusked green ears per plot. Kernels from this subsample were cut to full depth, squeezed with a press, and the juice was centrifuged at 5,000 rpm for 1 minute just to separate the extract from debris. Total soluble solids (Brix content, an indicator of sugar concentration) within the supernatant of the juice were measured with refractometer (Pocket Refractometer, Atago Company, India.). Grain yield per plant and hundred grain weight were recorded after harvest at dry maturity stage as the average of five ears randomly selected from each plot. This biochemical observations were taken in the Biochemistry Lab of Directorate of Maize Research, New Delhi and recorded with the help of near infra red spectroscopy. The combining ability analysis was carried out by the procedure given by Griffing [5], Method II and Model I. Biometrical genetic analysis was computed using SPAR-1 software developed by Indian Agricultural Statistical Research Institute (IASRI), New Delhi.

The ANOVA revealed significant variation in the hybrids for all the agronomic and quality traits. The GCA and SCA variances were found significant for all the traits which implies that both additive and non-additive variances are important in manifestation of most of the traits under study (Table 1). A number of reports across maize types have revealed that most of the yield and quality traits contributing quantitative variation are governed by both GCA and SCA variances [6, 7]. Based on GCA effects the good general combiners were identified for each trait, with specific emphasis on those inbred lines showing high GCA for more than one trait (Table 2). On the basis of general combining ability effects, the IPSA-8761 was good general combiner for ten traits followed by IPSA-8752 and IPSA-8754, which were good general combiners for seven traits. Inbred IPSA-8757 was good general combiner for five traits, while IPSA-8760 and IPSA-8753 for four traits. In the same way, IPSA-8755 and IPSA-8758 were good general combiners for three and two traits respectively. A good GCA effect for quality and yield component traits was displayed by IPSA-8754 and IPSA-8755.

The additive parental effects measured by GCA effects in terms of fixable genetic variance are of practical use on account of their response to selection and possiblity of genetic enhancement of a genotype for specific attribute. On the other hand, SCA effects representing dominance and epistatic components are more relevant to the improvement of cross pollinated crops where commercial exploitation of heterosis is feasible. The specific crosses involving good general combiners having high SCA effects may be utilized for hybrid breeding, emphasizing on the importance of SCA effects (Table 3). Particularly for sweet corn, more attention needs to be given to the quality parameters and fresh ear weight for meeting the standards and requirements of consumers [8]. It is very interesting to know that the SCA variance is much higher than GCA variance for ear weight with and without husk. Proportionality, the error component was also very less than SCA variance (Table 1). This suggests that predominance of non-additive variance for these traits. The ear length, number of rows per ear, number of kernels per row, total soluble solids (TSS), plant height, and ear placement height also showed similar trend. This indicates the non-additive gene action is more important for kernel biochemical composition on account of specific interaction of parental inbred lines involved in the cross as observed earlier [9]. The SCA variance is not fixable and not stable also. Although no cross exhibited significant SCA effect for grain yield (dry kernel stage), but for days to 50% tasseling and silking, days to 75% maturity, green ear weight with husk, without husk and for quality trait so many crosses showed significant SCA effect. For example, for days to 50% tasseling and silking, and days to 75% maturity the crosses like IPSA-8753xIPSA-8755, IPSA-8753xIPSA-8761, IPSA-8754xIPSA-8758 and IPSA-8756xIPSA-8758 showed significant SCA effects indicating earliness. Some of the crosses like IPSA-8752xIPSA-8756, IPSA-8752xIPSA-8757 and IPSA-8753xIPSA-8759 showed significant SCA effect for

Table 1. GCA and SCA variances of various agronomic and quality trait of sweet corn inbred lines

Para-meters	Days to 50% tasseling	Days to 50% silking	Days to 75% maturity	Ear wt. with husk (gm)	Ear wt. without husk (gm)	Ear wt. length (cm)	Ear breadth (cm)	No. of rows/ ear	No. of kernels/ row	Total soluble solids (TSS)	Plant ht. (cm)	Ear placement ht. (cm)	100-seed weight (gm)	Grain yield/ plant (gm)	Total sugar
GCA	10.18**	6.97**	10.04**	577.29**	652.79**	2.09**	0.14**	0.84**	6.73**	1.38*	278.52**	117.72**	1.57**	48.90**	4.44**
SCA	3.52**	2.61**	3.18**	1293.70**	919.91**	2.97**	0.08*	1.55**	14.91**	2.35**	367.15**	142.02**	0.86**	39.05**	1.81**
Error	0.93	0.74	0.98	27.92	24.46	0.17	0.01	0.28	1.76	0.34	24.06	14.38	0.18	6.4	0.3
σ^2_g	0.51	0.34	0.53	–55.11	–20.55	–0.07	0.00	–0.06	–0.63	–0.07	–6.82	–1.87	0.05	0.76	0.2
σ^2_s	2.59	1.87	2.2	1265.78	895.45	2.8	0.07	1.28	13.15	2.01	343.09	127.64	0.68	32.65	1.52
σ^2_e	0.93	0.74	0.98	27.92	24.46	0.17	0.01	0.28	1.76	0.34	24.06	14.38	0.18	6.4	0.3
σ^2_D	2.59	1.87	2.2	1265.78	895.45	2.8	0.07	1.28	13.15	2.01	343.09	127.64	0.68	32.65	1.52
σ^2_A	10.18	6.97	10.04	577.29	652.79	2.09	0.14	0.84	6.73	1.38	278.52	117.72	1.57	48.9	4.44

*=Significant at P=0.05 and **: P=0.01 level respectively

Table 2. GCA effects for agronomic and quality traits of eleven parents

Parents	Days to 50% tasseling	Days to 50% silking	Days to 75% maturity	Ear wt. with husk (gm)	Ear wt. without husk (gm)	Ear wt. length (cm)	Ear breadth (cm)	No. of rows/ ear	No. of kernels/ row	Total soluble solids (TSS)	Plant ht. (cm)	Ear placement ht. (cm)	100-seed weight (gm)	Grain yield/ plant (gm)	Total sugar
P1	0.71	0.06	0.82**	1.95	2.22	-0.18**	–0.05	–0.38**	0.75**	0.00	0.37	–1.30	–0.71**	–0.34	–1.34**
P2	–1.14*	–0.51**	–1.00**	2.51	0.39	0.17**	–0.04	0.02	0.34**	–0.52**	–4.90**	–2.36*	0.19**	1.13**	–0.03
P3	0.53	0.47**	0.17*	–2.81	–2.15	–0.12**	0.04	0.26**	0.14	–0.08	–4.14**	0.15	0.19**	2.33**	–0.03
P4	0.09	–0.07	0.12	3.40	3.33	0.76**	0.08	0.53**	1.46**	0.28**	2.41	2.32*	0.30**	3.42**	0.66**
P5	0.58	0.49**	0.82**	–0.52	–2.51	0.26**	–0.09	–0.09	–0.20	0.53**	9.37**	4.44**	0.45**	0.55	–0.51**
P6	0.63	0.96**	0.53**	–9.56**	–11.69**	0.19**	0.03	–0.07	0.31**	–0.41**	2.15	1.92	–0.14**	–0.05	–0.14
P7	–0.34	–0.79**	–0.57**	9.63**	11.30**	–0.18**	–0.01	–0.01	–0.32**	–0.38**	–0.54	–0.59	0.33**	–0.28	0.07
P8	1.07*	0.96**	0.97**	–11.03**	–11.01**	–0.49**	–0.07**	0.05	0.02	0.16**	–0.23	–1.87	–0.10	–2.97**	0.52**
P9	–0.57	–0.40**	–0.80**	–5.79**	–2.67	–0.39**	–0.09**	0.01	–0.77**	0.00	–6.47**	–3.26**	–0.36**	–2.37**	-0.23
P10	0.27	0.24*	0.61**	5.89**	6.23**	–0.48**	–0.08**	–0.36**	–0.91**	0.23**	4.90**	4.74**	–0.23**	–1.98**	0.39*
P11	–1.83**	–1.40**	–1.67**	6.34**	6.58**	0.46**	0.27**	0.05	–0.81**	0.20**	–2.91	–4.18**	0.08	0.57	0.65**
SE	0.06	0.05	0.07	1.95	1.71	0.012	0.001	0.02	0.12	0.02	1.68	1.01	0.012	0.44	0.02

*=Significant at P=0.05 and **: P=0.01 level respectively (P1: IPSA-8751, P2: IPSA-8752, P3: IPSA-8753, P4: IPSA-8754, P5: IPSA-8755, P6: IPSA-8756, P7: IPSA-8757, P8: IPSA-8758, P9: IPSA-8759, P10: IPSA-8760 and P11: I PSA-8761)

Table 3. SCA effects of agronomic and quality traits of selected diallel crosses

Hybrids	Days to 50% tasseling	Days to 50% silking	Days to 75% maturity	Ear wt. with husk (gm)	Ear wt. without husk (gm)	Ear wt. length (cm)	Ear breadth (cm)	No. of rows/ ear	No. of kernels/ row	Total soluble solids (TSS)	Plant ht. (cm)	Ear placement ht. (cm)	100-seed weight (gm)	Grain yield/ plant (gm)	Total sugar
P2 x P6	−1.50	0.59	−1.09	7.76	1.00	0.31*	-0.13	1.85**	2.15	−0.17	−10.28	−3.99	−1.06**	5.65	2.25**
P2 x P7	−1.53	−0.34	−1.32	42.67	33.47	1.61**	0.22	−0.21	2.85	2.77**	9.04	3.73	1.19**	6.92	2.70**
P3 x P5	−3.45**	−2.26**	−3.22**	−5.02	−9.91	−1.16**	0.45**	1.96**	−0.60	−1.13**	−15.06	−12.31	0.04	−1.29	−0.17
P3 x P9	−2.97**	−1.03	−2.60**	44.10	42.00*	2.31**	0.01	0.33	−0.26	0.05	17.55	7.09	0.14	4.94	2.17**
P3 x P10	−1.15	−0.34	−1.01	50.33*	48.09*	0.94**	−0.22	−0.57*	1.57	1.39**	−5.45	−7.31	1.40**	7.21	0.19
P3 x P11	−2.71**	−2.03**	−2.40**	−15.15	−19.07	−1.77**	−0.05	1.36**	−0.92	0.42	20.42	8.04	0.36*	3.85	1.03**
P4 x P7	−0.09	0.23	−0.12	50.19*	51.67*	−0.87**	−0.17	0.87**	−0.40	0.80**	−3.44	−2.59	−0.08	−0.28	0.98**
P4 x P8	−4.50**	−2.85**	−3.99**	0.47	−2.87	0.00	−0.25	−0.25	2.87	2.23**	1.25	−4.91	−0.67**	0.28	−0.94**
P4 x P10	−0.38	−1.47*	−0.96	−24.83	−25.24	−0.68**	0.51**	0.15	−0.55	−2.35**	1.13	4.21	−1.12**	0.21	1.28**
P4 x P11	0.73	−0.16	0.65	55.84*	55.37**	1.35**	0.25**	0.28	3.06*	1.37**	−7.70	−12.30	−0.83**	3.85	−0.31
P5 x P8	0.68	−0.08	0.32	57.61*	55.84**	2.08**	0.07	0.11	4.92**	1.43**	6.30	11.70	1.45**	7.05	0.83**
P6 x P8	−4.04**	−2.54**	−4.06**	10.40	5.87	0.84**	−0.11	−0.58*	1.41	−1.20**	13.18	−0.92	0.02	−3.95	0.27
P7 x P9	−0.43	−1.44*	−1.86*	28.39	55.93**	−0.33*	0.23	0.33	−4.40**	−1.90**	−2.86	−5.57	0.82**	3.28	1.44**
P8 x P11	−0.58	−0.18	−0.86	3.23	−4.76	1.32**	0.04	0.50*	0.73	0.03	−6.72	0.26	−0.09	−1.87	1.47**
P9 x P10	−2.04*	−0.47	−2.37**	−11.84	−9.66	2.50**	0.15	0.41	−0.78	−0.06	−14.69	−7.57	−0.77**	−4.94	1.41**
SE	0.79	0.63	0.84	23.97	21.01	0.14	0.01	0.23	1.51	0.28	20.66	12.35	0.15	54.94	0.25

*=Significant at P=0.05 and **: P=0.01 level respectively; P1: IPSA-8751, P2: IPSA-8752, P3: IPSA-8753, P4: IPSA-8754, P5: IPSA-8755, P6: IPSA-8756, P7: IPSA-8757, P8: IPSA-8758, P9: IPSA-8759, P10: IPSA-8760 and P11: IPSA-8761

sugar content and IPSA-8755/ IPSA-8758 and IPSA-8754/ IPSA-8757 for ear weight with husk, without husk and sugar content. The cross IPSA-8753/ IPSA-8759 showed significant SCA effect for ear weight without husk and sugar content which is desirable trait combination for sweet corn cultivars.

Comparative performance of the crosses was assessed using two established checks, Priya and Madhuri, which are commercially cultivated throughout India [10]. Non-significant difference in grain yield (at dry kernel stage) may be attributed to the fact that all the genotypes belonged to sweet corn group. The loss of moisture and consequent shrivellness led to insignificant difference among the tested hybrids. So, in general the present investigation revealed that both the dry grain yield and sugar content cannot be improved simultaneously by conventional breeding and hence a non-conventional approaches such as Marker Assisted Selection (MAS) targetting the specific mutants enhancing sweetness (*su, sh2, se* etc) may be practiced. Kumari *et al*. [11] reported the possibility of over-dominance effect for grain yield and suggested population improvement of inbred lines in case to have significant high GCA variance for sugar content are observed. In the present study, sweet corn quality parameters have shown significant non-additive variance which hints at the possibility of development of hybrids to improve these traits by enhancing the *per se* performance of the inbred lines. It is suggested that two separate programmes may be initiated in sweet corn one, to identify the crosses which show significant SCA effect for both sugar content and grain yield and second, the recurrent selection strategy could be followed for improvement of the other complementary traits in each of the two groups. This would result in enhancement of sweetness in high productivity genotypes and increasing yield in the genotypes with desirable sweetness.

Acknowledgement

Senior author is thankful to University Grants Commission (UGC) for providing financial assistance in the form of Rajiv Gandhi National Senior Research Fellowship for a Ph. D. programme.

References

1. **Sturtevant E. L.** 1989. Varieties of corn. USDA Experimental Station Bulletin, 57.
2. **Tracy W.F. and Hallauer A. R.** 1994. Sweet corn in ‘Speciality corns’ SRC Press Inc., Boca Raton, USA. 148-187.
3. **Gadag R. N., Meena C.R., Kumari J., Singh R. D. and Singh B. B.** 2006. Utility of filed corns for improvement of sweet corns-Analysis and Approaches. Souvenir of National convention on ‘Knowledge-driven agricultural development: Management of change’. Organized by ARS forum, March 24-26, New Delhi S-I, 12, 41- 42.
4. **Srdic J., Pajic Z. and Mladenovic S. D.** 2007. Inheritance of maize grain yield components. Maydica, **52**: 261-264.
5. **Griffing B.** 1956b. A generalized treatment of the use of diallel crosses in quantitative inheritance. Heredity, **10**: 31-50.
6. **Hemavathy T. and Balaji K.** 2008. Analysis of combining ability and heterotic groups of white grain quality protein maize (QPM) inbreds. Crop Res., **36**: 224-234.
7. **Katna G., Singh H. B., Sharma J. K. and Guleria S. K.** 2005. Heterosis and combining ability studies for yield and its related traits in maize (*Zea mays* L.). Crop Res., **30**: 221-226.
8. **Revilla P. and Tracy W. F.** 1997. Heterotic patterns among open pollinated sweet corn cultivars. J. Americ. Soc. Horti. Sci., **122**: 319-324.
9. **Has V.** 1999. Genetic analysis of some yield components and kernel quality in sweet corn. Rom. Agri. Res., **11**: 9-15.
10. **Khanduri A., Hossain F., Lakhere P. C. and Prasanna B. M.** 2011. Effect of harvest time on kernel sugar concentration in sweet corn. Indian J. Genet., **71**: 231-234.
11. **Kumari J., Gadag R. N. and Jha G. K.** 2009. Combining ability and gene action of grain yield and kernel quality traits in sweet corn (*Zea mays* L.). Res. On Crops, **10**: 323-332.