Annals of Agri-Bio Research **28** (1): 61-65, 2023

Impact Score : 0.28 (Scopus)

Combining Ability Estimates in Roselle (*Hibiscus sabdariffa* L.) for Seed Yield and Yield Contributing Traits

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(Received: July 10, 2022; Accepted: August 16, 2022)

ABSTRACT

A study was conducted to identify the parents with good general combining ability and specific cross combinations for seed yield and its nine attributing traits in roselle crop by utilizing 6 x 6 full diallel model at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. Parents and F_1's were grown in randomized block design with two replications. Analysis of variance for parents showed significant difference for all the characters except base diameter, while for hybrids significant differences for all the traits except plant height. Significant differences for gca and sca were exhibited in the characters plant height, mid diameter, number of pods, number of seeds per pod, test weight and seed yield suggesting presence of maternal effect of parents in their offsprings for these characters. For most of the characters, σ^2sca was found to be greater than σ^2 gca except for days to 50% flowering which could be suggested that all these characters were predominantly influenced by non-additive gene action. Among the six parents, AS 80-6 and AR-14 were found to be good general combiners for seed yield. The crosses, R-225 x AR-81, R-225 x R-180 and R-225 x AR-14 had recorded high *per se* performance for seed yield among the studied hybrids.

Key words: Combining ability, seed yield, gene effects, roselle

INTRODUCTION

Jute and mesta are the major bast fibre crops in India. Commercial jute is cultivated from two species viz., tossa jute (*Corchorus olitorius*) and white jute (*C. capsularis*) belonging to the family Teliaceae. Likewise, mesta is also cultivated from two species viz., roselle (*Hibiscus sabdariffa*) and kenaf (*Hibiscus cannabinus*) belonging to the family Malvaceae and the major share of mesta area is occupied by roselle. The bast fibre extracted from both jute and mesta is called as raw jute and production of raw jute is calculated in bales (1 bale=180 kg; Satyanarayana *et al.,* 2017).

In India, during 2020-21, mesta was cultivated in 53,000 ha with a productivity of 1646 kg/ha and production of 4.85 lakh bales (Anonymous, 2020). Till date, only little efforts were made in crop improvement of roselle for fibre yield; and very low efforts for seed yield studies. Genetic investigation of transmission of various important characters has remained far from being fully explored; this is due to the fact that there is insufficient genetic information on various species and cultivars of roselle.

The concept of combining ability plays a significant role in crop improvement, since it helps the breeder to determine the nature and magnitude of gene action involved in the inheritance of traits (Prasad *et al.*, 2018). Combining ability studies are very important in identification of desirable parents having good general combining ability and also to identify specific crosses with superior yields and also to find out the gene action for different yield and yield attributing traits. Hence, the present study was undertaken with the objective of finding out general combining ability and specific combining ability among parents and crosses in roselle for seed yield.

MATERIALS AND METHODS

Six selected parents were crossed in full diallel fashion generating 30 crosses (including 15 F_1 hybrids and 15 F_1 reciprocals). Emasculation was done during evening and crossing during morning hours of next day with all the possible combinations among six parents during December and matured pods bearing hybrid seeds were harvested after maturity. The study was conducted at Mandouri farm, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. Thirty hybrids (including reciprocals) along with six parents were sown in randomized block design with two replications at spacing of 30 x 10 cm and plot size of two rows of 4 m length. Good crop was maintained by following recommended package of practices and five plants were randomly selected for recording the observations. Data for days to 50% flowering were recorded before harvesting (plot-wise); and the data for plant height, base diameter, mid diameter, top diameter, number of nodes, number of pods, number of seeds per pod, test weight and seed yield were recorded after harvest (plant-wise). Data analysis was done based on Griffings by utilizing Indostat Statistical software.

RESULTS AND DISCUSSION

The mean performance of parents, hybrids and reciprocals for seed yield and seed yielding traits is presented in Table 1 and found significant differences among the hybrids for all the characters studied. Variance due to gca and sca was found significant for plant height, mid diameter, number of pods, number of seeds per pod, test weight and seed yield (Table 2). Significant variation for only gca variance was

Table 1. Mean performance of parents, hybrids and reciprocals in roselle

Hybrid/cross	Days to 50% flowering	Plant height (cm)	Base diameter (mm)	Mid diameter (mm)	Top diameter (mm)	No. of nodes	No. of pods	No. of seeds/ pod	Test weight (g)	Seed yield (g)
AR-14	172.00	275.50	13.10	9.90	4.52	58.00	27.60	33.10	2.38	10.85
AR-14 x AR-81	176.00	326.50	18.30	13.87	5.46	63.00	17.50	32.20	2.53	7.13
AR-14 x R-180	170.50	300.00	15.33	11.89	5.20	70.00	21.10	33.30	2.36	8.27
AR-14 x R-225	176.50	325.00	18.44	14.53	6.69	70.00	10.30	28.60	2.29	3.36
AR-14 x AS-80-6	174.50	292.00	16.40	12.50	6.05	53.50	14.70	35.30	2.32	6.02
AR-14 x REX-45	174.00	322.00	18.50	14.02	6.80	59.50	16.30	35.50	2.36	6.83
AR-81 x AR-14	175.00	335.00	18.26	15.10	6.07	70.00	16.20	31.30	2.48	6.28
AR-81	167.50	310.00	13.11	10.27	5.00	51.50	18.10	26.00	2.12	4.98
AR-81 x R-180	173.00	306.00	15.23	11.63	5.69	63.00	21.60	30.40	2.49	8.20
AR-81 x R-225	175.00	273.00	13.93	10.35	5.40	54.50	21.70	30.90	2.45	8.21
AR-81 x AS-80-6	172.50	320.00	18.14	14.05	6.13	61.00	19.90	32.80	2.32	7.54
AR-81 x REX-45	175.00	316.00	17.43	12.88	6.48	62.50	11.00	29.80	2.49	4.06
R-180 x AR-14	176.00	282.00	13.20	10.51	5.59	55.50	25.40	28.20	2.61	9.28
R-180 x AR-81	178.00	323.50	16.46	12.30	6.19	63.00	6.00	27.70	2.55	2.11
R-180	176.50	266.00	12.59	9.87	5.41	68.00	8.60	28.80	2.49	3.09
R-180 x R-225	176.50	346.00	19.28	14.44	5.56	64.50	11.20	30.50	2.62	4.47
R-180 x AS-80-6	177.00	290.00	16.33	12.45	5.58	64.00	24.20	32.50	2.55	9.98
R-180 x REX-45	180.50	306.50	18.19	12.48	6.44	61.50	23.00	28.90	2.52	8.33
R-225 x AR-14	169.50	331.00	21.05	14.19	6.96	70.50	27.90	29.90	2.48	10.38
R-225 x AR-81	175.00	292.00	15.54	11.77	6.11	59.50	32.20	32.00	2.34	12.08
R-225 x R-180	180.50	296.00	15.32	12.20	5.94	61.00	28.20	29.20	2.61	10.77
R-225	177.50	307.00	16.40	12.08	6.56	57.50	20.60	25.40	2.33	6.12
R-225 x AS-80-6	176.50	296.00	16.72	12.24	5.67	58.00	24.40	29.50	2.28	8.26
R-225 x REX-45	179.00	302.00	16.20	11.91	5.47	60.50	11.40	32.70	2.41	4.51
AS-80-6 x AR-14	170.00	290.00	15.53	11.84	5.43	60.00	15.10	35.50	2.42	6.49
AS-80-6 x AR-81	169.50	290.00	15.74	12.14	5.62	61.00	23.40	32.10	2.44	9.12
AS-80-6 x R-180	170.00	308.50	17.03	13.40	6.26	66.50	25.20	31.10	2.44	9.60
AS-80-6 x R-225	173.00	303.00	15.69	12.70	5.90	59.50	19.20	31.50	2.38	7.15
AS-80-6	176.50	275.00	15.46	12.06	6.39	60.00	20.00	30.80	2.41	7.43
AS-80-6 x REX-45	179.00	320.50	17.31	13.92	6.94	68.00	18.20	32.10	2.38	6.99
REX-45 x AR-14	176.00	290.00	15.66	11.91	5.29	61.00	18.60	34.20	2.42	7.67
REX-45 x AR-81	179.50	299.00	14.39	12.01	5.26	67.00	19.60	35.40	2.40	8.30
REX-45 x R-180	178.50	279.00	15.31	10.56	4.86	62.00	12.90	28.20	2.37	4.31
REX-45 x R-225	181.50	313.00	16.07	13.10	6.23	65.00	12.90	30.70	2.43	4.81
REX-45 x AS-80-6	175.00	281.00	13.47	11.13	4.99	57.00	18.40	34.30	2.42	7.61
REX-45	187.00	252.00	13.55	9.31	4.80	56.50	22.00	33.30	2.09	7.59
General mean	173.00	273.00	14.35	9.65	4.46	56.00	15.10	34.50	1.83	4.68
Parent mean	176.00	295.00	14.75	10.52	5.30	67.50	15.70	33.00	2.26	5.88
Hybrid mean	175.00	305.00	13.37	11.52	5.16	65.00	19.50	32.00	2.24	6.07
C. D. (P=0.05)	6.42	40.28	3.06	1.98	1.21	9.73	5.38	3.31	0.11	1.76
C.V. (%)	1.82	6.68	9.60	8.13	10.54	7.82	13.99	5.26	2.32	12.20
S. Em	2.26	14.17	1.08	0.70	0.43	3.42	1.89	1.17	0.04	0.62

Table 2. Analysis of variance of combining ability and fixed effects in roselle (*Hibiscus sabdariffa* L.) for seed yield

Source of variation	d. f.	Days to 50% flowering	Plant height (cm)	Base diameter (mm)	Mid diameter (mm)	Top diameter (mm)	No. of nodes	No. of pods	No. of seeds/ pod	Test weight (g)	Seed yield (g)
gca	5	60.88**	471.60*	2.34	1.54**	0.35	18.39	18.38**	21.82**	284.61**	3.28**
sca	15	7.34	573.30**	5.41**	3.16**	0.36*	31.74**	39.20**	5.36**	153.71**	5.77**
Reciprocal	15	8.74	288.18	2.66	1.15**	0.44**	17.05	39.89**	2.92*	66.46**	6.07**
Error	35	5.18	186.73	1.13	0.40	0.11	10.86	3.10	1.33	14.22	0.38
σ^2 gca		4.64	23.74	0.10	0.10	0.02	0.63	1.27	1.71	22.53	0.24
σ^2 sca		2.17	386.57	4.28	2.77	0.20	20.87	36.10	4.02	139.49	5.40
σ^2 reciprocal		1.78	50.73	0.77	0.38	0.14	3.09	18.39	0.79	26.12	2.85
σ^2A		9.28	47.48	0.20	0.19	0.03	1.25	2.55	3.42	45.07	0.48
σ^2D		2.17	386.57	4.28	2.77	0.20	20.87	36.10	4.02	139.49	5.40
h^2 narrow sense		0.50	0.07	0.03	0.05	0.06	0.04	0.04	0.36	0.20	0.05
h^2 broad sense		0.62	0.65	0.70	0.79	0.43	0.61	0.64	0.78	0.82	0.65
gca/sca ratio		2.14	0.06	0.02	0.04	0.08	0.03	0.04	0.42	0.16	0.05
Predictability ratio		0.81	0.11	0.05	0.07	0.14	0.57	0.07	0.46	0.24	0.08

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

evident for the characters days to 50% flowering, while significant variance for sca was found for base diameter, top diameter and number of nodes. This indicated that days to 50% flowering was controlled by additive gene effects, whereas base diameter, top diameter and number of nodes were controlled by non-additive gene effects and rest of the characters were influenced by both additive and non-additive gene effects. Combining ability for reciprocals was exhibited in the characters mid diameter, top diameter, number of pods, number of seeds per pod, test weight and seed yield which suggested presence of maternal effect of parents in their off springs for these characters. For most of the characters σ^2 sca was found to be greater than σ^2 gca except for days to 50% flowering suggesting that all these characters were predominantly influenced by non-additive gene action, whereas days to 50% flowering was controlled by additive gene action which was also indicated from gca/sca ratio as well as predictability ratio for all these characters. Similar results were depicted by Kodomi *et al.* (2019), while estimating combining ability in roselle, Varghese and Patel (2020) in cotton and Narkhede *et al.* (2021) in okra.

Parents with good combining ability played an important role for any crop improvement programme. Parent, AR-14, was a good combiner for days to 50% flowering, number of seeds per pod and seed yield; and average combiner for all the other characters; parent AR-81 was a good combiner for days to 50% flowering only; and average combiner for all the other characters except number of seeds per pod and test weight; parent R-180 was a good combiner for number of nodes and test weight; and average combiner for days to 50% flowering, plant height, base diameter and top diameter; parent R-225 was a good combiner for base diameter, mid diameter, top diameter and number of pods, whereas average combiner for days to 50% flowering, plant height, number of nodes, test weight and seed yield; parent AS 80-6 was a good combiner for days to 50% flowering, number of pods, number of seeds per pod and seed yield, whereas average combiner for all the other characters; and parent REX 45 was a good combiner for number of seeds per pod and average combiner for plant height, base diameter, top diameter and nodes per plant (Table 3). Sharma *et al.* (2017) identified AMV 1, AMV 5, GR 27 and AHS 160 as good combiners in roselle.

Specific combining ability (sca) effects for all the 30 crosses for seed yielding characters are presented in Table 4. The sca effects ranged from -2.75 to 3.92 (days to 50% flowering), -32.39 to 25.00 (plant height), -1.75 to 2.66 (base diameter), -1.53 to 2.01 (mid diameter), -0.45 to 0.98 (top diameter), -4.61 to 8.1 (number of nodes), -6.17 to 8.80 (number of pods), -2.80 to 2.55 (number of seeds per pod) and -12.75 to 11.14 (test weight). The sca effects for seed yield ranged from -3.51 (R-225 x AR-14) to 3.21 (AR-81 x R-225). Out of 30 hybrids, six hybrids recorded significant desirable sca effects and 10 hybrids recorded significant undesirable sca effects. The hybrids, R-225 x AR-81 (12.08 g), R-225 x R-180 (10.77 g), R-225 x AR-14 (10.38 g), R-180 x AS-80-6 (9.98 g) and R-180 x AR-14 (9.28 g) showed high *per se* performance for

Table 3. General combining ability effects of parents for yield and yield component characters in roselle (*Hibiscus sabdariffa* L.)

Parents	Days to 50% flowering	Plant height (cm)	Base diameter (mm)	Mid diameter (mm)	Top diameter (mm)	No. of nodes	No. of pods	No. of seeds/ pod	Test weight (g)	Seed yield (g)
AR 14	-2.04*	2.60	0.33	0.25	-0.09	0.65	0.84	1.30*	0.36	0.61*
AR 81	-1.92*	7.31	-0.27	-0.05	-0.10	-1.14	-0.24	-0.66*	-2.10*	-0.26
R 180	0.58	-3.65	-0.50	-0.46*	-0.13	2.15*	-1.02*	-1.41*	9.15*	-0.38*
R 225	0.96	6.47	0.68*	0.37*	0.28*	-0.26	1.03*	-1.52*	-0.43	0.02
AS 80-6	-1.38*	-6.03	0.03	0.28	0.14	-1.06	1.21*	1.14*	-1.81	0.63*
REX 45	3.79*	-6.69	-0.27	-0.39*	-0.11	-0.35	-1.83*	1.15*	-5.18*	-0.62*

*Significant at P=0.05.

Table 4. Specific combining ability effects of hybrids of roselle (*Hibiscus sabdariffa* L.) for seed yield

S. No.	Hybrid/cross	Days to 50% flowering	Plant height (cm)	Base diameter (mm)	Mid diameter (mm)	Top diameter (mm)	No. of nodes	No. of pods	No. of seeds/ pod	Test weight (g)	Seed yield (g)
1.	AR-14 x AR-81	3.92**	19.74*	2.14**	2.01**	0.15	5.22*	-2.77*	-0.10	10.85**	-0.82*
2.	AR-14 x R-180	-0.83	-9.06	-1.64*	-0.85*	-0.19	-1.82	4.41**	-0.35	-2.65	1.37**
3.	AR-14 x R-225	-1.46	17.82*	2.66**	1.48**	0.83**	8.10**	-1.79	-1.74**	-3.32	-0.93*
4.	AR-14 x AS-80-6	0.13	-6.68	-0.47	-0.62	-0.12	-4.61*	-6.17**	1.74**	-2.94	-2.16**
5.	AR-14 x REX-45	-2.29	8.99	0.94	0.84*	0.44*	-1.82	-0.58	1.18	2.18	0.09
6.	AR-81 x AR-14	0.50	-4.25	0.02	-0.62	-0.30	-3.50	0.65	0.45	2.50	0.43
7.	AR-81 x R-180	1.29	9.99	0.55	0.21	0.37	0.22	-3.96**	-0.09	3.31	-1.38**
8.	AR-81 x R-225	0.42	-32.39**	-1.75**	-1.53**	-0.23	-3.36	7.14**	2.42**	0.64	3.21**
9.	AR-81 x AS-80-6	-1.25	2.61	1.10	0.60	0.04	1.43	1.67	0.76	0.51	0.79
10.	AR-81 x REX-45	-0.17	5.78	0.38	0.61	0.27	4.47*	-1.65	0.90	9.89**	-0.11
11.	R-180 x AR-14	-2.75	9.00	1.06	0.69	-0.20	7.25**	-2.15	2.55**	-12.75**	-0.50
12.	R-180 x AR-81	-2.50	-8.75	-0.62	-0.34	-0.25	0.00	7.80**	1.35	-2.75	3.05**
13.	R-180 x R-225	1.42	17.07*	1.05	1.15**	-0.21	-0.90	0.67	1.57*	11.14**	0.82*
14.	R-180 x AS-80-6	-1.25	7.82	1.07	0.85*	0.10	2.39	5.49**	0.86	0.26	2.37**
15.	R-180 x REX-45	-0.42	1.99	1.45*	0.10	0.08	-1.82	1.78	-2.40**	-1.36	0.15
16.	R-225 x AR-14	3.50*	-3.00	-1.31	0.17	-0.13	-0.25	-8.80**	-0.65	-9.50**	-3.51**
17.	R-225 x AR-81	0.00	-9.50	-0.81	-0.71	-0.36	-2.50	-5.25**	-0.55	5.50*	-1.94**
18.	R-225 x R-180	-2.00	25.00*	1.98**	1.12*	-0.19	1.75	-8.50**	0.65	0.25	-3.15**
19.	R-225 x AS-80-6	-0.38	-2.06	-0.58	-0.44	-0.45*	-1.69	0.54	-0.34	-6.40**	-0.11
20.	R-225 x REX-45	-0.04	6.61	-0.35	0.26	-0.13	1.60	-6.08**	0.86	5.97*	-1.91**
21.	AS-80-6 x AR-14	2.25	1.00	0.43	0.33	0.31	-3.25	-0.20	-0.10	-5.00	-0.23
22.	AS-80-6 x AR-81	1.50	15.00	1.20	0.96*	0.26	0.00	-1.75	0.35	-6.00*	-0.79*
23.	AS-80-6 x R-180	3.50*	-9.25	-0.35	-0.48	-0.34	-1.25	-0.50	0.70	5.50*	0.19
24.	AS-80-6 x R-225	1.75	-3.50	0.52	-0.23	-0.12	-0.75	2.60*	-1.00	-4.75	0.56
25.	AS-80-6 x REX-45	-0.96	12.36	-0.44	0.37	0.13	2.14	-0.10	-0.31	5.35*	0.12
26.	REX-45 x AR-14	-1.00	16.00	1.42	1.06*	0.76**	-0.75	-1.15	0.65	-2.75	-0.42
27.	REX-45 x AR-81	-2.25	8.50	1.52**	0.44	0.61*	-2.25	-4.30**	-2.80**	4.50	-2.12**
28.	REX-45 x R-180	1.00	13.75	1.44	0.96*	0.79**	-0.25	5.05**	0.35	7.50**	2.01**
29.	REX-45 x R-225	-1.25	-5.50	0.06	-0.60	-0.38	-2.25	-0.75	1.00	-0.75	-0.15
30.	REX-45 x AS-80-6	2.00	19.75*	1.92*	1.40**	0.98**	5.50*	-0.10	-1.10	-1.75	-0.31

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

seed yield with involvement of average x average, average x poor, average x good, poor x good and poor x good mating parents, respectively. These results are in line with the findings of Anil *et al.* (2016) in tossa jute, Sharma *et al.* (2017) in roselle, Anil *et al.* (2018) in tossa jute and Anita *et al.* (2020) in tossa jute.

CONCLUSION

It is evident that most of the important triats responsible for seed yield were influenced by both additive and non-additive gene effects. The parents AS 80-6 and AR 14 exhibited high gca effects for seed yield and its attributing traits and these parents can be utilized further for improving seed yield in roselle. The crosses, R-225 x AR-81 (12.08 g), R-225 x R-180 (10.77 g), R-225 x AR-14 (10.38 g), R-180 x AS-80-6 (9.98 g) and R-180 x AR-14 (9.28 g) showed high *per se* performance for seed yield. These crosses can be utilized for exploitation of heterosis breeding in roselle crop improvement for seed yield.

ACKNOWLEDGEMENTS

The authors are highly thankful to authorities of BCKV, Mohanpur and AINPJAF centre, BCKV for providing necessary infrastructural facilities and timely support to undertake this project.

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