Environment and Ecology 40 (2B) : 665—671, April—June 2022
ISSN 0970-0420

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

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Received 31 January 2022, Accepted 18 March 2022, Published on 20 April 2022

ABSTRACT

A study was conducted to identify the parents with good general combining ability and specific cross combinations for fiber yield and its nine attributing traits in roselle crop by utilizing 6 × 6 full diallel model at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during *kharif* 2014. Parents and F_1's were grown in Randomized Block Design with two replications and analysis of variance for parents showed significant difference for all characters except base diameter, while for hybrids showed significant differences for all the traits except plant height. Significant differences for reciprocals were exhibited in the characters mid diameter, top diameter, internodal length, bark thickness, green weight, dry stick weight and fiber yield which suggested presence of maternal effect of parents in their offsprings for these characters. For most of the characters $\sigma^2 sca$ was found to be greater than $\sigma^2 gca$ except for days to 50% flowering and internodal length which could be suggested that all these characters were predominantly influenced by non-additive gene action. Among the six parents, R 225 was found to be a good general combiner for most of the fiber yielding characters followed by AR 14. The crosses, R-180 × R-225, AR-14 × AR-81, AR-81 × AS-80-6, AR-14 × R-225 and AR-14 × REX-45 had exhibited highly significant positive *sca* effects for fiber yield and its attributing characters.

Keywords Combining ability, Fiber yield, Gene effects, Roselle.

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INTRODUCTION

Jute and Mesta are the major bast fiber crops in India; commercial jute is cultivated from two species viz., tossa jute (*Corchorus olitorius*) and white jute (*C. capsularis*) belongs to the family Teliaceae : likewise, mesta is also cultivated from two species, viz., roselle (*Hibiscus sabdariffa*) and kenaf (*Hibiscus cannabinus*) which belongs to the family Malvaceae and the

Table 1. Mean performance of parents, hybrids and check varieties in rosell.

High brid/cross	Days to 50% flower-ing	Plant height	Base diame-ter	Mid diame-ter	Top diame-ter	Inter-nodal length	Bark thick-ness	Green weight	Dry stick weight	Fiber yield
AR-14	172.00	275.50	13.10	9.90	4.52	6.23	1.54	181.50	17.70	10.20
AR-14 ×AR-81	176.00	326.50	18.30	13.87	5.46	5.72	1.64	410.50	48.80	20.84
AR-14 × R-180	170.50	300.00	15.33	11.89	5.20	5.46	1.47	290.00	32.20	13.15
AR-14 × R-225	176.50	325.00	18.44	14.53	6.69	5.71	1.94	377.50	50.80	19.38
AR-14 × AS-80-6	174.50	292.00	16.40	12.50	6.05	6.15	1.75	332.50	34.40	14.60
AR-14 × REX-45	174.00	322.00	18.50	14.02	6.80	5.93	1.86	411.00	48.50	20.49
AR-81 × AR-14	175.00	335.00	18.26	15.10	6.07	6.07	1.77	384.50	50.00	19.57
AR-81	167.50	310.00	13.11	10.27	5.00	6.02	1.30	208.50	25.20	10.33
AR-81 × R-180	173.00	306.00	15.23	11.63	5.69	6.11	1.41	290.50	36.10	15.45
AR-81 × R-225	175.00	273.00	13.93	10.35	5.40	6.77	1.54	225.00	27.20	11.04
AR-81 × AS-80-6	172.50	320.00	18.14	14.05	6.13	6.53	1.88	333.50	51.30	19.63
AR-81 × REX-45	175.00	316.00	17.43	12.88	6.48	5.80	1.76	329.50	38.30	17.86
R-180 ×AR-14	176.00	282.00	13.20	10.51	5.59	6.26	1.59	203.00	24.10	9.84
R-180 × AR-81	178.00	323.50	16.46	12.30	6.19	5.77	1.45	323.00	41.00	17.13
R-180	176.50	266.00	12.59	9.87	5.41	5.07	1.39	188.00	22.80	9.59
R-180 × R-225	176.50	346.00	19.28	14.44	5.56	5.80	1.52	469.50	58.10	23.60
R-180 × AS-80-6	177.00	290.00	16.33	12.45	5.58	5.50	1.63	297.50	32.40	13.50
R-180 × REX-45	180.50	306.50	18.19	12.48	6.44	5.36	1.67	375.50	41.00	18.38
R-225 × AR-14	169.50	331.00	21.05	14.19	6.96	5.42	2.05	511.00	57.70	23.82
R-225 × AR-81	175.00	292.00	15.54	11.77	6.11	5.92	1.54	281.00	31.90	13.80
R-225 × R-180	180.50	296.00	15.32	12.20	5.94	5.63	1.77	310.00	40.50	14.52
R-225	177.50	307.00	16.40	12.08	6.56	5.88	1.71	350.50	42.50	16.59
R-225 × AS-80-6	176.50	296.00	16.72	12.24	5.67	6.10	1.59	320.50	35.10	13.87
R-225 × REX-45	179.00	302.00	16.20	11.91	5.47	5.68	1.67	338.00	44.70	16.04
AS-80-6 × AR-14	170.00	290.00	15.53	11.84	5.43	5.68	1.70	279.50	28.50	13.13
AS-80-6 × AR-81	169.50	290.00	15.74	12.14	5.62	5.96	1.58	303.00	34.90	13.87
AS-80-6 × R-180	170.00	308.50	17.03	13.40	6.26	5.02	1.85	361.00	40.70	16.63
AS-80-6 × R-225	173.00	303.00	15.69	12.70	5.90	6.12	1.68	320.50	35.10	13.25
AS-80-6	176.50	275.00	15.46	12.06	6.39	5.72	1.55	271.00	27.50	11.01
AS-80-6 × REX-45	179.00	320.50	17.31	13.92	6.94	5.09	1.83	399.50	42.90	18.38
REX-45 × AR-14	176.00	290.00	15.66	11.91	5.29	5.42	1.70	282.50	30.90	14.05
REX-45 × AR-81	179.50	299.00	14.39	12.01	5.26	4.87	1.51	288.50	35.10	14.47
REX-45 × R-180	178.50	279.00	15.31	10.56	4.86	5.16	1.33	241.00	27.10	11.83
REX-45 × R-225	181.50	313.00	16.07	13.10	6.23	5.39	1.51	406.00	48.60	19.21
REX-45 × AS-80-6	175.00	281.00	13.47	11.13	4.99	6.14	1.41	222.50	23.20	10.50
REX-45	187.00	252.00	13.55	9.31	4.80	4.99	1.31	158.00	17.50	9.92
General mean	175.43	300.10	15.89	12.10	5.70	5.71	1.59	306.73	36.34	14.98
Parent mean	176.17	280.92	14.03	10.58	5.44	5.65	1.47	226.25	25.53	11.27
Hybrid Mean	175.42	305.15	16.48	12.60	5.87	5.75	1.65	330.58	39.04	16.06
CD (0.05)	6.42	40.28	3.06	1.98	1.21	0.76	0.21	75.81	7.35	3.40
CV (%)	1.82	6.68	9.60	8.13	10.54	6.63	6.44	12.30	10.07	11.29
SEm	2.26	14.17	1.08	0.70	0.43	0.27	0.07	26.67	2.59	1.20

major share of mesta area is occupied by roselle. The bast fiber extracted from both jute and mesta is called as raw jute and production of raw jute is calculated in bales (1 bale = 180 kg).

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 little efforts were made in crop improvement of roselle as the available genetic variation is very low. 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

Table 2. Analysis of variance for parents and hybids in roselle (*Hibiscus sabdariffa* L.). * Significant at 0.05 level. ** Significant at 0.01 level.

Source of variation	df	Days to 50% flowering	Plant height	Base diameter	Mid diameter	Top diameter	Inter nodal length	Bark thickness	Green weight	Dry stick weight	Fiber yield
Replication	1	0.13	174.22	3.02	3.08	0.01	0.02	0.007	3226.72	9.53	3.57
Treatments	35	31.18**	873.15**	7.58**	4.13**	0.79**	0.40**	0.07**	12893.81**	226.47**	30.91**
Parents	5	84.73**	1059.68*	4.67	2.84**	1.45**	0.52*	0.052*	10351.75**	170.09**	14.00**
Hybrids	29	22.83*	668.59	6.27**	3.09**	0.64*	0.39**	0.06**	10023.11**	181.13**	26.99**
Parent vs. Hybrids	1	5.63	5872.54**	59.94**	40.78**	1.85*	0.10	0.34**	108854.45**	1823.40**	229.06**
F_1's	14	14.06	665.71	4.44	2.96**	0.66*	0.38*	0.50**	7555.63**	153.91**	24.14**
Reciprocals	14	32.89**	640.61	7.18**	3.11**	0.63*	0.37*	0.07**	12093.32**	196.26**	27.32**
F_1 vs. Reciprocals	1	4.82	1100.82	19.29**	4.60*	0.55	0.55	0.03	15584.82**	350.42**	62.47**
Error	35	10.35	373.45	2.25	0.79	0.32	0.16	0.02	1324.44	13.35	2.93
Total	71	20.48	616.97	4.89	2.47	0.58	0.33	0.04	7054.44	118.36	16.73

species and cultivars of roselle (Louis *et al.* 2013). 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

Table 3. Analysis of variance of combining ability and fixed effects in roselle (*Hibiscus sabdariffa* L.). * Significant at 0.05 level ** Significant at 0.01 level.

Source of variation	df	Days to 50% flowering	Plant height	Base diameter	Mid diameter	Top diameter	Internodal length	Bark thickness	Green weight	Dry stick weight	Fiber yield
GCA	5	60.88**	471.60*	2.34	1.54**	0.35	0.59**	778.26**	6033.62**	122.60**	11.26**
SCA	15	7.34	573.30**	5.41**	3.16**	0.36*	0.10	447.33**	8507.98**	164.69**	21.01**
Reciprocal	15	8.74	288.18	2.66	1.15**	0.44**	0.16*	275.97**	4523.59**	58.66**	11.30**
Error	35	5.18	186.73	1.13	0.40	0.11	0.08	36.73	662.22	6.67	1.46
σ2gca		4.64	23.74	0.10	0.10	0.02	0.04	61.79	447.62	9.66	0.82
σ2sca		2.17	386.57	4.28	2.77	0.20	0.03	410.60	7845.76	158.02	19.55
σ2 reciprocal		1.78	50.73	0.77	0.38	0.14	0.04	119.62	1930.69	25.99	4.92
σ2A		9.28	47.48	0.20	0.19	0.03	0.09	123.59	895.23	19.32	1.63
σ2D		2.17	386.57	4.28	2.77	0.20	0.03	410.60	7845.76	158.02	19.55
h^2 Narrow Sense		0.50	0.07	0.03	0.05	0.06	0.37	0.18	0.08	0.09	0.06
h^2 Broad Sense		0.62	0.65	0.70	0.79	0.43	0.48	0.77	0.77	0.84	0.77
GCA/SCA Ratio		2.14	0.06	0.02	0.04	0.08	1.68	0.15	0.06	0.06	0.04
Predictability ratio		0.81	0.11	0.05	0.07	0.14	0.77	0.23	0.10	0.11	0.08

Table 4. General combining ability effects of parents for yield, yield component characters in roselle (*Hibiscus sabdariffa* L.).

Source of variation	Days to 50% flowering	Plant height	Base diameter	Mid diameter	Top diameter	Internodal length	Bark thickness	Green weight	Dry stick weight	Fiber yield
AR 14	-2.04*	2.60	0.33	0.25	-0.09	0.12	8.75*	7.22	-0.01	0.51
AR 81	-1.92*	7.31	-0.27	-0.05	-0.10	0.23*	-7.04*	-14.36*	0.30	0.10
R 180	0.58	-3.65	-0.50	-0.46*	-0.13	-0.22*	-9.33*	-18.44*	-1.89*	-0.83*
R 225	0.96	6.47	0.68*	0.37*	0.28*	0.12	9.58*	41.81*	6.11*	1.55*
AS 80-6	-1.38*	-6.03	0.03	0.28	0.14	0.08	1.96	-3.86	-2.33*	-1.15*
REX 45	3.79*	-6.69	-0.27	-0.39*	-0.11	-0.33*	-3.92*	-12.36	-2.18*	-0.18

and specific combining ability among parents and crosses, respectively in roselle.

MATERIALS AND METHODS

Six parents were selected and crossed in full diallel fashion and generated 30 crosses (includes 15 F_1 hybrids and 15 F_1 reciprocals). Emasculation was done during evening period and crossing during morning hours of next day with all the possible combinations among six parents during December 2013 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 during 2014-15. Thirty hybrids (including reciprocals) along with six parents were sown in Randomized Block Design with two replications with a spacing of 30 × 10 cm and plot size of two rows of 4m length and maintained a good crop by following recommended package of practices and five randomly selected plants were selected for recording the observations. Data for days to 50% flowering recorded before harvesting (plot wise) and the data of plant height, base diameter, mid diameter, top diameter, internodal length, bark thickness, green weight were recorded after harvest (plant wise) and plant wise data of dry stick weight and fiber yield recorded after retting. Data analysis was done based on Griffing (1956) by utilizing Indostat Statistical software.

RESULTS AND DISCUSSION

Significant differences were observed for fiber yield and fiber yielding traits based on the mean performance of parents, hybrids and reciprocals (Table 1). The variance due to treatments (considering six parents and thirty hybrids) was found highly significant for all the characters studied (Table 2). Analysis of variance for parents were found significant for all the characters except base diameter; while for hybrids showed significant variance for all the characters except for plant height which indicated the presence of significant differences among parents and hybrids for most of the yield attributing characters. Parents vs hybrids exhibited significant variation for all the characters except days to 50% flowering and internodal length. Variance due to F_1's and reciprocal was found significant for mid diameter, top diameter, internodal length, bark thickness, green weight, dry stick weight and fiber yield and other than these characters reciprocals also showed significant variation for days to 50% flowering and base diameter. The presence of significant variation among parents, crosses, F_1's and reciprocals indicated potential genetic differences among parents and their prepotency. The two single degree comparisons i.e., hybrids vs reciprocals and parents vs crosses signified the presence of considerable reciprocal differences and could increase the possibility in resultant hybrid progenies. Variance due to F_1's vs reciprocal interaction was significant for the characters base diameter, mid diameter, green weight, dry stick weight and fiber yield. This suggested presence of maternal effects in some hybrids for these characters. These results corroborated with the findings of Singh *et al.* (1987) in linseed, Rahima *et al.* (2010) in white jute and Reddy *et al.* (2013) in okra. The reciprocal differences are important because on the basis of it desirable female parent

Table 5. Specific combining ability effects of hybrids of roselle (*Hibiscus sabdariffa* L.).

Sl. No.	Hybrid / cross	Days to 50% flow-ering	Plant height	Base dia-meter	Mid dia-meter	Top dia-meter	Inter-nodal length	Bark thick-ness	Green weight	Dry stick weight	Fiber yield
1	AR-14 × AR-81	3.92**	19.74*	2.14**	2.01**	0.15	-0.19	6.00	91.44**	12.33**	4.33**
2	AR-14 × R-180	-0.83	-9.06	-1.64*	-0.85*	-0.19	0.22	-18.21**	-55.47**	-6.74**	-3.45**
3	AR-14 × R-225	-1.46	17.82*	2.66**	1.48**	0.83**	-0.42*	28.38**	82.03**	11.37**	4.28**
4	AR-14 × AS-80-6	0.13	-6.68	-0.47	-0.62	-0.12	-0.02	-1.00	-10.56	-3.00	-0.76
5	AR-14 × REX-45	-2.29	8.99	0.94	0.84*	0.44*	0.15	10.63**	38.69*	5.10**	1.68*
6	AR-81 × AR-14	0.50	-4.25	0.02	-0.62	-0.30	-0.18	-6.50	13.00	-0.60	0.64
7	AR-81 × R-180	1.29	9.99	0.55	0.21	0.37	0.19	0.58	26.36	3.35*	1.76*
8	AR-81 × R-225	0.42	-32.39**	-1.75**	-1.53**	-0.23	0.26	-11.08**	-87.64**	-13.64**	-4.49**
9	AR-81 × AS-80-6	-1.25	2.61	1.10	0.60	0.04	0.20	9.54*	23.28	8.34**	2.54**
10	AR-81 × REX-45	-0.17	5.78	0.38	0.61	0.27	-0.30	13.17**	22.53	1.79	0.98
11	R-180 × AR-14	-2.75	9.00	1.06	0.69	-0.20	-0.40*	3.00	43.50*	4.05*	1.66
12	R-180 × AR-81	-2.50	-8.75	-0.62	-0.34	-0.25	0.17	-6.00	-16.25	-2.45	-0.84
13	R-180 × R-225	1.42	17.07*	1.05	1.15**	-0.21	0.07	13.46**	53.19**	8.29**	3.08**
14	R-180 × AS-80-6	-1.25	7.82	1.07	0.85*	0.10	-0.33	12.83**	38.36*	3.98*	1.78*
15	R-180 × REX-45	-0.42	1.99	1.45*	0.10	0.08	0.08	8.46*	25.86	1.33	0.85
16	R-225 × AR-14	3.50*	-3.00	-1.31	0.17	-0.13	0.15	-15.00**	-66.75**	-3.45	-2.22*
17	R-225 × AR-81	0.00	-9.50	-0.81	-0.71	-0.36	0.43*	-0.25	-28.00	-2.35	-1.38
18	R-225 × R-180	-2.00	25.00*	1.98**	1.12*	-0.19	0.09	-0.50	79.75**	8.80**	4.54**
19	R-225 × AS-80-6	-0.38	-2.06	-0.58	-0.44	-0.45*	0.18	-10.83**	-30.64	-5.46**	-2.10**
20	R-225 × REX-45	-0.04	6.61	-0.35	0.26	-0.13	0.01	-9.46*	29.36	5.94**	0.99
21	AS-80-6 × AR-14	2.25	1.00	0.43	0.33	0.31	0.24	2.50	26.50	2.95	0.74
22	AS-80-6 × AR-81	1.50	15.00	1.20	0.96*	0.26	0.28	9.25*	15.25	8.20**	2.88**
23	AS-80-6 × R-180	3.50*	-9.25	-0.35	-0.48	-0.34	0.24	-17.25**	-31.75	-4.15*	-1.57
24	AS-80-6 × R-225	1.75	-3.50	0.52	-0.23	-0.12	-0.01	-4.50	0.00	0.00	0.31
25	AS-80-6 × REX-45	-0.96	12.36	-0.44	0.37	0.13	0.14	1.17	14.03	0.77	0.50
26	REX-45 × AR-14	-1.00	16.00	1.42	1.06*	0.76**	0.26	7.75	64.25**	8.80**	3.22**
27	REX-45 × AR-81	-2.25	8.50	1.52**	0.44	0.61*	0.47*	13.50**	20.50	1.60	1.70
28	REX-45 × R-180	1.00	13.75	1.44	0.96*	0.79**	0.10	24.50**	67.25**	6.95**	3.28**
29	REX-45 × R-225	-1.25	-5.50	0.06	-0.60	-0.38	0.15	8.00	-34.00	-1.95	-1.59
30	REX-45 × AS-80-6	2.00	19.75*	1.92*	1.40**	0.98**	-0.53*	21.00	88.50**	9.85**	3.94**

can be chosen in hybridization program particularly during production of commercial hybrids.

Variance due to GCA and SCA were found significant for plant height, mid diameter, bark thickness, green weight, dry stick weight and fiber yield (Table 3). Significant variation for only GCA variance was evident for the characters days to 50% flowering and inter nodal length, while significant variance for SCA were found for base diameter and top diameter. This indicated that days to 50% flowering and inter nodal length were controlled by additive gene effects whereas base diameter and top diameter 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 were exhibited in the characters mid diameter, top diameter, inter nodal length, bark thickness, green weight, dry stick weight and fiber yield which suggested presence of maternal effect of parents in their off-springs for these characters. For most of the characters $\sigma^2 sca$ was found to be greater than $\sigma^2 gca$ except for days to 50% flowering and inter nodal length which could be suggested that all these characters were predominantly influenced by non-additive gene action whereas days to 50% flowering and inter nodal length were controlled by additive gene action which was also been indicated from *gca/sca* ratio as well as predictability ratio for all these characters. Sengupta *et al.* (2005) reported similar results for fiber yield and fiber quality traits in tossa jute. Mostofa *et al.* (2011) in kenaf for fiber characters indicated the involvement of both additive and non-additive gene actions in the inheritance of triats. Similar results were depicted by Louis and Simon (2013) while estimating combining ability in roselle.

Parents with good combining ability plays an important role for any crop improvement programs. General combining ability (GCA) effects for six parents for different characters were presented in Table 4. Parent, AR 14, was a good combiner for days to 50% flowering and bark thickness and average combiner for all the other characters including fiber yield; parent AR 81 was a good combiner for days to 50% flowering and internodal length and average combiner for all the other characters except bark thickness and green weight; parent R 180 was an average combiner for days to 50% flowering, plant height, base diameter and top diameter; parent R 225 was a good combiner for all traits except for days to 50% flowering, plant height and inter nodal length for which it was an average combiner; parent AS 80-6, was a good combiner for days to 50% flowering and average combiner for all the other characters except dry stick weight and fiber yield and parent REX 45 was an average combiner for plant height, base diameter, top diameter, green weight and fiber yield. Thirthamallappa and Sheriff (1992) reported AMV-2 as best general combiner in roselle for fiber yield. Mostofa *et al.* (2011) suggested that parent Acc. 2731 was best general combiner for fiber yield and its attributes in kenaf. 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 fiber yielding characters were presented in Table 5. The *sca* effects for fiber yield ranged from -4.49 (AR-81 × R-225) to 4.54 (R-225 × R-180). Out of 30 hybrids, twelve hybrids recorded significant desirable *sca* effects and four hybrids recorded significant undesirable sca effects. Significant positive *sca* effects with high *per se* performance for fiber yield was found in cross R-180 × R-225 (23.60 g/plant) followed by AR-14 × AR-81 (20.84 g/plant), AR-81 × AS-80-6 (19.63 g/plant) and AR-14 × R-225 (19.38 g/plant), with involvement of poor × good, average × average, average × poor and average ×good mating parents respectively.

The cross, R-180 × R-225 also recorded highly significant desirable *sca* effects for plant height, mid diameter, bark thickness, green weight and dry stick weight which are the major fiber yield characters; likewise, the cross AR-14 × AR-81 also recorded highly significant desirable *sca* effects for plant height, base diameter, mid diameter, green weight and dry stick weight which are the major fiber yield characters; similarly, the cross AR-81 × AS 80-6 also recorded highly significant desirable *sca* effects for bark thickness and dry stick weight which are important for fiber yield and in the same way, the cross AR-14 × R-225 also recorded highly significant desirable *sca* effects for plant height, base diameter, mid diameter, top diameter, bark thickness, green weight and dry stick weight which are the major fiber yield characters. These results were in line with the findings of Rahima *et al.* (2010) in white jute, Mostofa *et al.* (2011) in kenaf, 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.

From the present study, it is evident that most of the important triats responsible for fiber yield were influenced by both additive and non-additive gene effects. The parents R 225, AR 14 and AR 81 exhibited high *gca* effects for fiber yield and its attributing traits and these parents can be utilized further for improving fiber yield in roselle. The crosses, R-180 x R-225 followed by AR-14 × AR-81, AR-81 × AS-80-6 and AR-14 × R-225 recorded significant positive sca effects with high *per se* performance for fiber yield. These crosses can be utilized for exploitation of heterosis breeding in roselle crop improvement for fiber yield.

ACKNOWLEDGEMENT

The authors are highly thankful to the authorities of Bidhan Chandra Krishi Viswavidyalaya and AINP-JAF unit, BCKV for providing all the facilities for conducting this experiment.

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