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Genetic Variability, Inter-Relationship and Path Analysis for Seed Yield and it's Contributing Traits in Roselle (*Hibiscus sabdariffa* L.) Over Six Environments

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A B S T R A C T

Roselle (*Hibiscus sabdariffa* L.) is an important commercial crop among bast fibres in India after jute and till date almost nil efforts were made in terms of crop improvement aspects pertaining to seed yield in roselle as it majorly utilized as fibre crop. To acquire first hand information on seed yield and its contributing traits, a set of sixty genotypes of roselle have been used to study the genetic variability, heritability, correlation and path analysis for seed yield and its contributing traits during 2013 and 2014 at three different agro-climatic zones of India. Phenotypic as well as genotypic coefficients of variability (PCV and GCV) were high for the trait pods per plant and seed yield; whereas, medium for base diameter and low for days to 50% flowering. Medium heritability coupled with high expected genetic gain was observed for pods per plant and seed yield. Seed yield was found to be positively and highly significant with pods per plant, base diameter and plant height both at genotypic and phenotypic levels; whereas, only at phenotypic level for seeds per pod and test weight. Partitioning of correlation coefficients of various components direct effects upon seed yield into direct and indirect contributions revealed that pods per plant has maximum direct effect upon seed yield followed by seeds per pod and test weight at both levels. High positive correlation coefficients for plant height and base diameter were due to indirect effects of pods per plant. Hence, selection for the traits pods per plant, seeds per pod, plant height and base diameter may be successful for seed yield improvement in roselle.

Introduction

Roselle (*Hibiscus sabdariffa* L.) belongs to the family Malvaceae; native to Asia (India to Malaysia) or Africa; and is an annual or biennial plant cultivated in Tropical and Sub-Tropical regions for its stem, fibres, edible calyces, leaves and seeds (Babatunde and Mofoke, 2006; Mahadevan *et al.*, 2009). Roselle is a tetraploid species with 2n=4x=72 (Sabiel *et al.*, 2014) and proved its importance in fibre industries, preparation of medicines and in culinaries to make favourable dishes from its edible parts in many countries. Two botanical types of roselle viz., *Hibiscus sabdariffa var. altissima* and *Hibiscus sabdariffa var. sabdariffa* exists of which *var. altissima* grown for its phloem fibre and *var. sabdariffa* for its fleshy calyces (Krishna Murthy *et al.*, 1992; Tejaswini *et al.*, 1995 and Ibrahim *et al.*, 2013). Roselle fibre blended with jute is used in the manufacture of jute goods viz., cordage, sacking, hessian, canvas and rough sacks, ropes, twines, fishing nets etc. The stalks were used in making paper pulp, structural boards, as a blend for wood pulp and thatching huts. The seed contains 18-20% oil and is used in soap and other industries (Juhi Agarwal and Ela Dedhia, 2014).

Roselle in India is the important bast fibre crop after jute in terms of area and production (Hariram and Appalaswamy, 2014). The major growing states of this crop are Andhra Pradesh, Bihar, Orissa, West Bengal and Maharashtra with an area of 84 thousand ha (during 2012-13) that produced 6.16 lakh bales (1bale = 180 kg) with an average productivity of about 13.20 q/ha (Sen and Karmakar, 2014). Since, roselle is mostly used for its fibre in India, efforts were made only on fibre yield and its contributing traits by researchers till date and there is every need to study on seed yield and its contributing characters also.

Generally, the success of any crop improvement program largely depends on the magnitude of genetic variability, genetic advance, character association, direct and indirect effects on yield and its attributes. Correlation and path coefficient analysis of traits will also help in component characters in a breeding programme whose selection would result in the improvement of complex traits that are positively correlated. Genetic variability and inter-relationship studies have been done in a wide range of fibre crops e.g. kenaf (Mostofa *et al.*, 2002; Echekwu and Showemino, 2004 and Ghodke and Wadikar, 2011), roselle (Pullibai *et al.*, 2005; Ibrahim and Hussein, 2006; Rani *et al.*, 2006; Bhajantri *et al.*, 2007; Ibrahim *et al.*, (2013) and Satyanarayana *et al.*, 2015), jute (Palve and Sinha, 2005 and Bhattacharya *et al.*, 2007) and okra (Murtadha *et al.*, 2004; Adeniji *et al.*, 2007 and Nwangburuka *et al.*, 2012) will provide the information on genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability, genetic advance and genetic advance as per cent mean (GAM), correlation between different characters with yield along with their direct and indirect effects on yield. In this context, the present investigation was undertaken to assess the genetic variability, heritability and genetic advance, character association and path coefficient analysis of the seed yield and its attributing traits of roselle by utilizing sixty genotypes.

Materials and Methods

Sixty roselle (*Hibiscus sabdariffa* L.) genotypes consisting of eleven exotic lines; four released varieties and 45 indigenous accessions were evaluated at three different agro-climatic environments viz., North Coastal zone, Andhra Pradesh at Agricultural Research Station, Ragolu (Latitude 18^0 24' N; Longitude 83. 84^0 E at an altitude of 27m above mean sea level); Indo-Gangetic zone, West Bengal at Instructional Farm, Bidhan Chandra Krishi Vishwavidyalaya, Jaguli (Latitude 22^0 93' N; Longitude 88. 59^0 E at an altitude of 9.75m above mean sea level) for first year and at Teaching farm, Mondauri, BCKV (Latitude 22^0 87' N; Longitude 88. 59^0 E at an altitude of 9.75m above mean sea level) for second year and Terai Zone, West Bengal at University Farm, Uttar Banga Krishi Vishwavidyalaya (Latitude 26^0 19' N; Longitude 89. 23^0 E at an altitude of 43m above mean sea level). The experiments were sown during early *kharif* seasons in 2013 and

2014 at the above three zones. The experimental trial was laid out in randomized block design in two replications with a plot size of four rows of 2m length with intra-row spacing of 10 cm and inter-row spacing of 30 cm accommodating 20 plants in a row. Recommended package of practices was followed to raise a good crop. Data on the basis of five randomly selected plants were recorded for plant height (cm), base diameter (mm), number of nodes per plant, days to 50% flowering, number of pods per plant, number of seeds per pod, test weight (g) and seed yield per plant (g).

The pooled data were subjected to analysis of variance following standard statistical methods (Singh and Choudhary, 1985). Genotypic and Phenotypic coefficients of variation (GCV and PCV) were calculated using the formula suggested by Burton and De Vane (1953). Heritability and genetic advance were estimated according to the formulae given by Allard (1960). Genotypic and phenotypic correlations were calculated as suggested by Johnson *et al.,* (1955). The phenotypic correlations were used to find out the direct and indirect effects of the component characters on fibre yield per plant, according to Dewey and Lu (1959).

Results and Discussion

The pooled mean performance of 60 roselle genotypes for eight seed yield related traits from six environments revealed significant difference among the genotypes for all the eight characters (Table 1). Mean data for each character along with range, genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability, genetic advance (GA) and genetic advance as per cent mean (GAM) was given in Table 2. Plant height ranged from 207.55 to 351.00cm, base diameter (14.64 to 19.77mm), nodes per plant (58.00 to 78.85), days to 50% flowering (161.58 to 182.83), pods per plant (10.08 to 28.48) seeds per pod (23.12 to 32.52), test weight (1.85 to 3.11) and seed yield (5.92 to 13.83g) which showed a wide range of variability for all the characters under study.

The GCV ranged from 5.058% (days to 50% flowering) to 33.503% (pods per plant) among eight traits studied; whereas, PCV ranged from 6.110% to 49.988% respectively for characters similar to GCV. Heritability in broad-sense ranged from 16.43% to 68.55% for characters test weight and days to 50% flowering, respectively. Similarly, GAM had a range between 4.539% to 46.528% for seeds per pod and pods per plant, respectively.

High values of PCV and GCV were recorded for the traits, pods per plant and seed yield suggesting high variability for these traits in the present study; whereas, the character base diameter exhibited moderate values of GCV and PCV. Days to 50% flowering showed lower values of GCV and PCV. The traits, plant height, nodes per plant, seeds per pod and test weight had exhibited moderate values for PCV and lower values for GCV which confirms the influence of environment on these traits. These findings are in agreement with Dastidar *et al.,* (1993), Islam *et al.,* (2002), Palve *et al.,* (2003), Echekwu and Showemino (2004), Ibrahim and Hussein (2006), Nwangburuka *et al.,* (2012), Ibrahim *et al.,* (2013) and Hari Satyanarayana *et al.,* (2017). The estimates of PCV were generally higher than their corresponding GCV for all the characters studied suggesting thereby the important role of environment in the expression of these traits. Hence, phenotypic selection may not hold good for genetic improvement in these traits.

Practically, heritability estimates are of greater value to the breeder, since, they indicate the degree of dependence of genotypic value on phenotypic value. Broad-sense heritability was high for character days to 50% flowering only; whereas, medium for most of the characters except seeds per pod and test weight. Similar results were also reported by Dastidar *et al.*, (1993), Mostofa *et al.*, (2002), Echekwu and Showemino (2004), Nwangburuka *et al.*, (2012), Ibrahim *et al.*, (2013) and Hari Satyanarayana *et al.*, (2017). The estimates of heritability, however, indicate only the effectiveness with which the selection of genotypes can be made based on their phenotypic performance, but fail to indicate the amount of progress expected from selection. For an effective selection, the knowledge alone on the estimates of heritability is not sufficient and genetic advance if studied along with heritability is more useful.

Genetic advance as percent of mean was higher for the traits pods per plant and seed yield; whereas, moderate for plant height, base diameter and nodes per plant and lower for the rest of characters. These findings were corroborated with the results of Dastidar *et al.*, (1993), Islam *et al.*, (2002), Nwangburuka *et al.*, (2012), Ibrahim *et al.*, (2013) and Hari Satyanarayana *et al.*, (2017). Greater influence of environment was noticed on the variability parameters of the accessions for different characters can be mainly attributed to the wide range of environments under which the study was undertaken.

Correlation between characters

The correlation coefficients at genotypic and phenotypic levels were estimated for different pairs of characters from their pooled data of sixty roselle genotypes (Table 3). The inter-character association with seed yield was significant for all characters at phenotypic level, whereas, significant for all characters except for nodes per plant, seeds per pod and test weight at genotypic level. Seed yield was highly significant with pods per plant (0.953 and 0.917), base diameter (0.657 and 0.398), plant height (0.488 and 0.348) in positive direction, both at genotypic and phenotypic levels; whereas, the trait days to 50% flowering was highly significant with seed yield in negative direction at both levels. However, the traits, nodes per plant, seeds per pod and test weight were significant positively at phenotypic level only and were non-significant at genotypic level.

Selections carried out based on the correlation studies are reliable only when there is significant association both at genotypic and phenotypic levels (Ibrahim and Hussein, 2006) for a particular trait with the dependent variable, yield. High genotypic correlation coefficients than the phenotypic correlation coefficients was observed for all characters suggesting strong relationship between these characters at genetic level.

Seed yield has highly significant positive associations with the traits like pods per plant (0.953 and 0.917), base diameter (0.657 and 0.398), plant height (0.488 and 0.348) at genotypic and phenotypic levels; whereas, the trait seeds per pod and test weight were positively significant with seed yield at phenotypic level only. These findings were in agreement with Dastidar *et al.*, (1993), Islam *et al.*, (2001), Palve *et al.*, (2003), Ali and Sasmal (2006), Nwangburuka *et al.*, (2012), Pervin and Haque (2012) and Ibrahim *et al.*, (2013). Plant height exhibited significant positive association with base diameter, nodes per plant, pods per plant and seeds per pod; whereas, base diameter exhibited positive significant association with plant height, nodes per plant and pods per plant. Pods per plant exhibited significant positive correlation with plant height, base diameter and nodes per plant. On the other hand, test weight has significant negative correlation with plant height, base diameter, nodes per plant, days to 50% flowering and seeds per pod.

Table.1 Mean data for seed yield and it's contributing traits of sixty genotypes of roselle (*Hibiscus sabdariffa* L.)

S. No.	Genotype	Plant height (cm)	Base diameter (mm)	Nodes / plant	Days to flowering	Pods per plant	Seeds per pod	Test weight (g)	Seed yield (g)
1	AR - 14	304.92	19.44	71.75	165.08	18.32	29.33	2.56	10.28
2	AR - 19	304.13	17.70	70.33	164.67	26.13	26.40	2.33	11.86
3	AR - 42	300.18	17.54	75.75	172.75	20.77	26.88	2.00	8.90
4	AR - 45	311.46	17.19	63.58	173.25	14.78	28.73	2.27	7.58
5	AR - 48	317.89	18.01	75.33	167.58	23.75	31.43	2.15	12.32
6	AR - 50	322.17	17.79	74.25	168.33	23.38	31.28	2.14	11.85
7	AR - 55	337.49	18.98	77.33	163.92	28.48	29.98	2.19	13.83
8	AR - 66	329.04	18.27	69.42	169.50	23.50	32.52	1.99	11.41
9	AR - 67	324.07	18.49	75.92	168.83	26.95	30.35	2.08	12.46
10	AR - 71	338.09	19.32	72.67	167.33	25.60	28.33	2.54	13.65
11	AR - 79	315.87	17.67	69.33	166.42	13.98	28.03	2.01	6.08
12	AR - 80	303.75	18.96	63.00	167.67	24.85	28.60	2.46	12.81
13	AR - 81	326.08	18.39	66.08	167.33	20.25	29.47	2.24	10.19
14	AR - 85	286.46	18.67	71.00	169.67	20.00	27.83	2.32	9.32
15	AR - 88	325.05	17.79	63.75	172.83	15.55	29.72	2.29	8.33
16	R - 16	322.79	18.28	65.92	168.00	21.05	28.98	2.56	11.80
17	R - 29	340.52	19.55	71.08	168.25	17.47	29.10	2.59	10.01
18	R 30	350.35	18.69	70.50	172.50	21.68	30.08	2.15	10.66
19	R - 37	338.50	18.52	68.42	176.58	25.95	31.38	2.18	13.15
20	R - 48	315.75	17.74	71.33	176.00	24.52	24.03	2.59	11.13
21	R - 67	310.86	19.50	64.25	167.92	19.20	26.85	2.49	9.25
22	R - 68	312.23	18.54	74.67	176.17	25.30	28.45	2.25	11.86
23	R - 77	299.57	16.13	67.17	175.67	15.45	28.30	2.17	7.28
24	R - 86	351.00	18.94	78.58	168.58	22.20	30.47	2.14	11.05
25	R - 134	299.25	19.43	69.58	177.50	23.03	29.98	2.39	12.45
26	R - 180	322.57	19.51	71.42	178.17	21.93	26.38	2.29	10.68
27	R - 225	328.82	19.57	65.42	173.33	24.63	23.58	2.40	10.29
28	R - 243	293.67	17.91	60.50	167.58	16.65	30.22	2.39	9.11
29	R - 271	336.78	18.68	68.42	175.67	20.13	31.80	1.97	9.57

30	R - 284	341.67	19.77	69.08	174.08	23.30	32.50	2.02	11.10
31	R - 318	336.53	17.76	73.92	173.00	20.33	29.83	2.08	9.68
32	R - 322	295.21	17.43	68.75	175.67	16.18	27.07	1.85	6.60
33	ER - 56	312.98	17.92	71.08	173.00	18.43	31.25	2.04	8.93
34	ER - 57	320.66	18.16	66.67	170.17	21.07	28.98	2.24	10.35
35	ER - 60	207.55	14.91	58.00	163.67	13.60	28.60	2.65	7.80
36	ER - 68	293.52	16.54	67.67	176.92	20.98	29.38	2.08	9.74
37	AS - 80 - 6	306.57	18.64	67.25	166.67	17.37	28.12	2.33	8.80
38	AS - 80 - 7	328.70	19.20	69.08	172.83	19.95	28.87	2.57	10.96
39	AS - 80 -	253.18	16.16	67.83	166.58	17.45	26.47	2.69	9.30
40	AS - 80 -	246.68	15.81	63.08	170.83	13.17	28.17	2.13	6.23
41	AS - 80 -	283.95	17.61	67.00	175.58	18.08	30.57	2.61	10.83
42	AS - 81 - 1	293.02	17.10	64.83	168.92	12.98	24.69	2.42	5.92
43	AS - 81 - 2	250.49	16.08	63.58	165.50	15.67	23.12	2.84	7.63
44	AS - 81 - 3	308.59	17.35	62.08	174.67	19.02	29.58	2.35	10.04
45	AS - 81 - 5	289.07	17.39	59.33	168.17	18.07	28.00	2.49	9.77
46	AS - 81 - 9	295.48	18.27	66.33	168.58	24.72	27.23	2.43	12.65
47	AS - 81 -	288.49	16.48	64.92	174.83	24.25	28.70	1.88	10.10
48	AS - 81 -	291.94	17.97	70.50	172.58	26.19	25.93	2.39	12.00
49	AS - 81 -	217.33	14.64	58.58	166.08	16.02	26.37	2.70	8.82
50	REX - 6	315.73	18.48	67.42	166.00	24.68	28.07	2.20	11.31
51	REX - 14	317.12	18.63	68.67	178.42	24.10	31.45	1.98	11.08
52	REX - 34	207.99	16.92	70.92	161.58	10.08	26.70	3.11	6.50
53	REX - 38	249.60	16.65	65.42	174.42	11.43	30.67	2.01	5.95
54	REX - 45	294.50	17.07	66.17	182.83	18.58	29.35	2.18	9.27
55	REX - 52	307.28	17.65	68.83	175.08	23.65	31.07	1.97	10.65
56	REX - 63	294.93	17.00	65.58	167.25	22.12	28.98	2.22	10.69
57	HS - 4288	330.41	18.31	64.33	173.42	21.08	32.18	1.98	10.13
58	AMV - 4	328.30	17.45	68.92	170.42	21.03	26.62	2.14	9.00
59	AMV - 5	330.01	17.96	64.83	170.50	19.90	31.38	2.25	10.73
60	AMV - 7	324.79	19.07	67.25	170.67	22.05	31.22	2.09	10.90
	Mean	305.53	17.93	68.08	170.93	20.35	28.83	2.28	10.04
	C.D. 5%	14.17	1.2	5.72	2.89	2.29	1.26	0.11	0.97

Table.2 Genetic variability parameters in roselle (*Hibiscus sabdariffa* L.) for seed yield and its contributing characters

Character	Mean	Range	GCV (%)	PCV (%)	Heritability	Genetic advance	GAM
Plant height (cm)	305.53	207.55 – 351.00	9.238	14.590	40.09	36.816	12.050
Base diameter (mm)	17.93	14.64 – 19.77	11.520	16.849	46.75	2.909	16.226
Nodes / plant	68.08	58.00 – 78.58	8.577	14.893	33.17	6.928	10.176
Days to 50% flowering	170.93	161.58 – 182.83	5.058	6.110	68.55	14.747	8.627
Pods per plant	20.35	10.08 – 28.48	33.503	49.988	44.92	9.414	46.528
Seeds per pod	28.83	23.12 – 32.52	5.302	12.756	17.27	1.309	4.539
Test weight (g)	2.28	1.85 – 3.11	5.949	14.676	16.43	0.113	4.967
Seed yield (g)	10.04	5.92 – 13.83	27.238	47.317	33.14	3.244	32.299

Table.3 Genotypic and Phenotypic correlation coefficients between seed yield and its component characters in roselle (*Hibiscus sabdariffa* L.)

Character		Plant height (cm)	Base diameter (mm)	Nodes / plant	Days to 50% flowering	Pods per plant	Seeds per pod	Test weight (g)	Seed yield (g)
Plant height (cm)	r_g	1.000	0.705**	0.579**	-0.209**	0.542**	0.192**	0.037	0.488**
	r_p	1.000	0.653**	0.471**	-0.023	0.405**	0.207**	-0.181**	0.348**
Base diameter (mm)	r_g		1.000	0.182**	-0.395**	0.759**	-0.207**	-0.140**	0.657**
	r_p		1.000	0.325**	-0.213**	0.470**	0.033	-0.057	0.398**
Nodes / plant	r_g			1.000	-0.047	0.082*	0.007	0.209**	-0.045
	r_p			1.000	-0.009	0.146**	0.045	-0.020	0.085*
Days to 50% flowering	r_g				1.000	-0.772**	0.342**	-0.172**	-0.679**
	r_p				1.000	-0.418**	0.182**	-0.210**	-0.333**
Pods per plant	r_g					1.000	-0.196**	0.030	0.953**
	r_p					1.000	0.051	-0.035	0.917**
Seeds per pod	r_g						1.000	-0.108**	0.013
	r_p						1.000	-0.200**	0.271**
Test weight (g)	r_g							1.000	0.072
	r_p							1.000	0.141**
Seed yield (g)	r_g								1.000
	r_p								1.000

r_g: Genotypic correlation coefficient r_p: Phenotypic correlation coefficient *Significant at 5% level **Significant at 1% level

Table.4 Direct and indirect contributions of component characters for seed yield in roselle (*Hibiscus sabdariffa* L.)

Character		Plant height (cm)	Base diameter (mm)	Nodes / plant	Days to flowering	Pods per plant	Seeds per pod	Test weight (g)	Correlation with seed yield
Plant height (cm)	G	**-0.0399**	-0.0695	-0.0684	-0.0321	0.6569	0.0378	0.0035	0.488**
	P	**-0.0230**	-0.0002	-0.0235	-0.0016	0.3842	0.0545	-0.0428	0.348**
Base diameter (mm)	G	-0.0282	**-0.0985**	-0.0216	-0.0607	0.9201	-0.0406	-0.0133	0.657**
	P	-0.0150	**-0.0003**	-0.0162	-0.0144	0.4497	0.0086	-0.0135	0.398**
Nodes / plant	G	-0.0231	-0.0180	**-0.1182**	-0.0072	0.0996	0.0015	0.0200	-0.045
	P	-0.0108	-0.0001	**-0.0498**	-0.0006	0.1396	0.0119	-0.0048	0.085*
Days to flowering	G	0.0084	0.0390	0.0055	**0.1536**	-0.9358	0.0672	-0.01648	-0.679**
	P	0.0005	0.0001	0.0005	**0.0678**	-0.3997	0.0479	-0.0496	-0.333**
Pods per plant	G	-0.0216	-0.0748	-0.0097	-0.1185	**1.2128**	-0.0384	0.0029	0.953**
	P	-0.0092	-0.0001	-0.0073	-0.0283	**0.9571**	0.0135	-0.0082	0.917**
Seeds per pod	G	-0.0077	0.0204	-0.0009	0.0525	-0.2371	**0.1964**	-0.0103	0.013
	P	-0.0048	0.0001	-0.0023	0.0123	0.0490	**0.2635**	-0.0473	0.271**
Test weight (g)	G	0.0015	0.0138	-0.0247	-0.0265	0.0362	-0.0212	**0.0956**	0.072
	P	0.0042	0.0001	0.0010	-0.0143	-0.0333	-0.0528	**0.2362**	0.141**

Bold: Direct effects Residual effect: 1.87 % (at Genotypic level) and 5.22% (at Phenotypic level)

With this study, it is confirmed that the traits plant height, base diameter, pods per plant and seeds per pod very important for seed yield as they showed highly significant positive correlation both at genotypic and phenotypic levels for most of the characters. Selections made based on these traits will be successful for higher seed yield in roselle.

Path analysis studies

Partitioning of correlation coefficients (both at genotypic and phenotypic levels) of various component characters with seed yield into direct and indirect contributions (Table 4) revealed that pods per plant has maximum direct effect (1.2128 and 0.9571) on seed yield followed by seeds per pod (0.1964 and 0.2635), days to 50% flowering (0.1536 and 0.0678) and test weight (0.0956 and 0.2362).

The high correlation coefficient of pods per plant (0.953 and 0.917 at genotypic and genotypic levels) with seed yield was totally due to the direct effects of pods per plant (1.2128 and 0.9571). The high correlation coefficient of base diameter (0.657 and 0.398) with seed yield was majorly due to the indirect effects of pods per plant (0.9201 and 0.4497). Likewise, the high correlation coefficient of plant height (0.488 and 0.348) with seed yield was also largely due to the indirect effects of pods per plant (0.6569 and 0.3842). Similarly, the high correlation coefficient of seeds per plant (0.271) at phenotypic level with seed yield was due to the direct effects of its own (0.2635). The direct effect of test weight (0.2362) at phenotypic level is solely responsible for highly significant correlation of test weight with seed yield. The negative correlation coefficient of days to 50% flowering at both levels (-0.679 and -0.333) was mainly due to the indirect effect of pods per plant (-0.9358 and -0.3997) in spite of the trait itself had a positive direct effect (0.1536 and 0.0678).

The relationship between traits explained through character association studies may not provide a clear picture of bonding between yield and its contributing traits. Path analysis provides lucid information of direct and indirect effects of traits and measures the relative importance of each and every trait in shaping the final objective, seed yield. The direct and indirect effects both at genotypic and phenotypic levels showed that pods per plant (1.2128 and 0.9571) had maximum direct effect followed by seeds per pod (0.1964 and 0.2635), days to 50% flowering (0.1536 and 0.0678) and test weight (0.0956 and 0.2362), respectively; whereas, nodes per plant has negative direct effect (-0.1182 and -0.0498). The positive and highly significant correlation of plant height and base diameter with seed yield were also mainly due to indirect effect of pods per plant rather than their direct effects. These results were corroborated with the findings of Dastidar *et al.*, (1993), Islam *et al.*, (2001), Echekwu and Showemino (2004) and Pervin and Haque (2012).

The value of residual effects was very low, 1.87% (genotypic correlation) and 5.22% (phenotypic correlation) suggesting that about 98% of genotypic total variation and 95% of phenotypic total variation for seed yield in roselle was explained and the remaining percent have not been studied in the present study. Finally, the path coefficient analysis revealed importance of pods per plant, seeds per pod and test weight for their contribution either directly or indirectly to seed yield and hence, during selection these traits should be given utmost attention for developing of high seed yielding roselle varieties.

In conclusion, selection based on the trait pods per plant proves very effective as the trait showed highest association with seed yield and have high positive direct effect and indirect effects through plant height and base diameter coupled with high GCV, PCV, medium heritability and high genetic gain along with seed yield. The other traits, such as plant height and base diameter may also be considered for selection as they have high positive association with seed yield both at genotypic and phenotypic levels. Therefore, emphasis should be given to the above traits during selection for evolving high seed yielding lines of roselle.

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