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GENETIC VARIABILITY, CHARACTER ASSOCIATION AND PATH ANALYSIS FOR FRUIT YIELD COMPONENTS AND QUALITY TRAITS IN EGGPLANT (*Solanum melongena* L.)

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SUMMARY

Biparental mating (BIP) attempted in the F_2 population of an eggplant cross Arka Keshav (AK) × Bhola Nath (BN) by using North Carolina Design-1. Two eggplant genotypes, Arka Keshav (AK) and Bhola Nath (BN), were selected on the basis of their contrasting characteristics. The experimental material consisted of forty eight biparental progenies (BIPs) developed in F_2 generations of an inter-varietal crosses *viz*., Arka Keshav × Bhola Nath (AK ×BN) and sixty F_3 progenies developed by selfing of plants used in the biparental mating. The biparental (BIPs) and F_3 progenies were then planted and evaluated along with corresponding original parents, F_1s and F_2s in two different experiments relating in randomized block design (RBD) with 3 replications at Experimental Farm, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *kharif* 2013. The results indicate that the mean values for all the traits were higher in BIP than in F_3 progenies. The range of expression was wider in biparental progenies and the upper limit of range was especially higher in BIP than in F_3 progenies for most of characters. At the same time, the lower limit was lower in BIP compared with F_3 progenies for most of the traits, suggesting that intermating causes more variability than selfing. Phenotypic variability in general, as revealed by the co-efficient of variation, was greater in biparental progenies as compared to F_3 progenies with a few exceptions for all the characters. The average mean performance of the biparental progenies was also superior to F_3 progenies for all the characters. The correlation coefficients between marketable fruit yield per plant and number of marketable fruits per plant, plant height and fruit weight were mostly positive and significant in BIPs and F_3 progenies. The path analysis revealed that it was mainly the direct effects of fruit weight, which contributed to its association with marketable fruit yield per plant in BIPs and F_3 progenies Hence, fruit weight appeared to be the most appropriate and rewarding character for the selection to operate on for obtaining high fruit yield in brinjal.

Key words: Biparental progenies, correlation coefficient, eggplant, North Carolina Design-1, path analysis, variability studies

Key findings: Good quantum of genetic variability has been generated through biparental progenies with respect to different traits studied as revealed by the analysis of variance of the biparental and F_3 progenies. The association studies revealed that marketable fruit yield was positively and significantly correlated with fruits per plant, plant height and fruit weight in BIPs and F_3 progenies. The preponderance of additive and non-additive genetic component of variance for different traits studied revealed the role of additive and non-additive gene action for the inheritance of marketable fruit yield, which is helpful in deciding breeding methods for improvement in brinjal.

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INTRODUCTION

Brinjal (*Solanum melongena* L.) also called as eggplant or aubergine is a member of family Solanaceae and one of the most commonly grown vegetables all the year round in the country (Hazra *et al.*, 2011). India is considered to be the centre of origin (Zeven and Zhukousky, 1975) with secondary diversity in China and South East Asia (Nath *et al*., 1987). India ranks second in area and production of brinjal in the world after China. The genetic improvement of any crop relies mainly on the presence of substantial magnitude of variability in the populations.

In often cross-pollinated crop like brinjal, the general breeding procedures have been to select desired segregants in the F_2 population and make plant to row selection in the subsequent generations. The genes for desirable characters are rapidly fixed in homozygous state in this procedure. However, the improvement by this method of breeding, besides being slow, is limited for desirable recombinations among the linked genes due to rapid approach to homozygosity (Humphrey *et al*., 1989). The routine breeding procedures are, thus, inadequate to explore the range of useful existing genetic variability for complex characters like yield. Biparental mating, on the other hand is expected to break larger linkage blocks and provide more chances for recombination to occur. It is a useful system of mating for generation of increased variability and may be applied where desired variation for traits of interest is lacking (Singh and Dwivedi, 1978). Biparental mating among the segregants in the F_2 of a cross may provide more opportunity for the recombination to occur, mop up desirable genes and as a result release concealed variability (Parameshwarappa *et al*., 1997). Inter-mating of randomly selected F_2 plants (biparental mating) in early segregating generations would not only help in creating new populations with high frequencies of rare combinations, but also retain greater variability by breaking undesirable linkages, for selection to be effective for a longer period. These considerations have encouraged us to use the approach of biparental mating in brinjal as suggested by Comstock and Robinson (1948 and 1952). The correlation between different characters is an important tool in the hands of plant breeder for making the crop improvement, whereas the path coefficient analysis partitions the correlation coefficients into direct and indirect effects. Johanson *et al.* (1955) stated that the estimates of genotypic and phenotypic correlation among the characters are useful in planning and evaluating breeding programme. The contribution of traits towards marketable fruit yield is further partitioned into direct and indirect effects through path coefficient analysis. In view of the above facts, an attempt has been made in this study to compare the performance of biparental progenies with respect to selfed generation in releasing genetic variability.

MATERIALS AND METHODS

The present investigations were carried out at the Experimental Farm, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (HP) during the *kharif* (rainy) seasons 2012 and 2013. The experimental material was developed from an intervarietal cross viz., Arka Keshav × Bhola Nath (AK × BN). The parents were selected on the basis of contrasting characters. Arka Keshav is mid maturing having erect plants with long purple glossy fruits, uniform in skin colour and borne in clusters; whereas Bhola Nath is having spreading growth habit with small purple round fruits with green tinge on surface.

Biparental progenies were developed in F_2 generation of intervarietal cross using North Carolina Design I as suggested by Comstock and Robinson (1948 and 1952). Materials were evaluated in RBD with three replications and observations recorded for marketable fruit yield per plant, days to 50% flowering, days to first picking, number of marketable fruits per plant, fruit length, fruit diameter, average fruit diameter, plant height, number of branches per plant, fruit weight, pedicel length, total soluble solids, dry matter content, iron content, phenol content and bacterial wilt incidence. The Vegetable Research Farm of CSKHPKV, Palampur is situated at an elevation of about 1290.8 meter above mean sea level with $32^0 6'$ North latitude and $76^0 3'$ East longitude, representing mid hills zone of Himachal Pradesh and has a sub-temperate climate with high rainfall during monsoon season. The soil of this zone is silt clay loam with acidic reaction. The biparental progenies (BIPs) and F_3 progenies were grown in Randomized Block Design (RBD) with three replications. Each experimental plot consisted of two rows of 2.70m length for biparental and F_3 progenies with inter and intra plant distance of 60 cm and 45 cm, respectively. These progenies were arranged in three sets, each comprising 16 BIPs and twenty F_3 progenies. The sets and progenies within the sets were randomized separately. In addition, six rows of each F_2, two rows each of the original parents and F_1s were also included in each replication for making comparisons. The F_2 seeds of intervarietal cross Arka Keshav × Bhola Nath (AK × BN) obtained from crosses attempted during *kharif* 2011 were sown during March, 2012. This material was used to produce seeds of biparental and F_3 progenies. The seeds of F_1 were also obtained by making fresh crosses. The final experiment was conducted during *kharif* 2013 with the experimental material comprising parents (P_1, P_2), F_1, F_2, BIP's and F_3 generations.

Transplanting was done after 6 weeks after thoroughly ploughing and levelling of the field. Farm yard manure @ 20 t/ha was added in the soil at the time of field preparation. The chemical fertilizers were applied in the soil before transplanting the crop as per recommended package of practices (100 kg N, 75 kg P_2O_5 and 50 kg K_2O / ha). One third of N and full dose of P_2O_5 and K_2O were applied before transplanting. Remaining two third N was top dressed in equal doses after 30 and 45 days after transplanting. The intercultural operations were carried out as per recommended package of practices. Regular weeding was carried out to keep the experimental field free from weeds and plant protection measures adopted to raise a healthy crop.

The method of analysis of variance followed was as proposed by Comstock and Robinson (1948 and 1952). The standard errors of σ^2m and σ^2f were calculated as follows by the formula proposed by Moll *et al.* (1960). The standard errors of σ^2A and σ^2D were calculated as followed by the method proposed by Panse and Sukhatme (1984). Expected gains from full-sib family selection were calculated by means of the procedure outlined by Robinson *et al.* (1949). An approximate procedure was used by Goodman (1965) to estimate the expected gains from mass selection. The phenotypic coefficients of correlation were computed as suggested by Al-Jibouri *et al.* (1958). The path coefficients at phenotypic level were calculated by employing the method suggested by Dewey and Lu (1959). The characterwise means of the biparental progenies (BIPs) were compared with the means of F_3 progenies.

The significance of difference between means was tested using 't' test.

$$t = \frac{\bar{x} - \bar{y}}{S\sqrt{1/n_1 + 1/n_2}}$$

$$S = \sqrt{\frac{(n_1-1)\bar{S_1}^2 + (n_2-1)\bar{S_2}^2}{n_1 + n_2 - 2}}$$

Where, $\bar{x}$ and $\bar{y}$ are the means of the same character in two populations; n_1 and n_2 were the number of BIPs and F_3 progenies, respectively. On the basis of which the characterwise means were found out; S was the pooled standard deviation and S_1 and S_2 were standard deviations of the two populations.

RESULTS AND DISCUSSION

Comparison of mean and range of expression of different characters between BIP and F_3 (Table 1) indicated that mean values of BIP were higher than mean values of F_3 for all the characters. The superior mean performance of biparental

Table 1. Range, mean, standard deviation and coefficient of variation for various traits in BIP and F_3 progenies in the cross Arka Keshav x Bhola Nath (AK x BN).

Traits	Range*		Standard deviation		Coefficient of variation (%)		Mean		Comparison of means through t-test
	BIP	F_3	BIP	F_3	BIP	F_3	BIP	F_3	t-ratio
Marketable fruit yield/plant (kg)	0.67-1.13	0.70-0.95	0.24	0.31	25.89	21.35	0.95	0.83	12.43*
Days to 50% flowering	49.09-63.73	49.94-59.50	2.33	2.91	4.09	5.37	56.97	54.20	8.53*
Days to first picking	51.54-72.69	54.56-70.74	1.98	1.75	3.06	2.85	64.79	61.49	8.18*
Number of marketable fruits per plant	10.65-17.92	12.71-17.66	2.34	3.52	15.41	13.53	15.19	14.96	1.23
Fruit length (cm)	9.38-18.09	11.49-16.72	0.89	0.91	6.01	6.54	14.81	13.91	4.25*
Fruit diameter(cm)	2.50-5.31	2.43-4.96	0.48	0.48	11.01	12.60	4.36	3.81	5.92*
Average fruit diameter (cm)	2.19-4.62	2.19-4.53	0.39	0.27	10.89	7.54	3.58	3.58	1.07
Plant height (cm)	74.91-101.37	79.78-97.83	2.55	1.37	2.79	1.59	91.23	86.37	7.09*
Number of branches per plant	6.24-8.58	6.62-7.66	0.87	0.57	10.70	7.29	8.13	7.82	2.23*
Fruit weight (g)	42.07-61.54	47.77-57.74	3.22	2.33	5.82	4.54	55.27	51.35	8.87*
Pedicel length (cm)	4.23-6.67	3.79-5.35	0.88	0.41	17.05	9.26	5.16	4.43	5.70*
Total soluble solids (%)	6.85-8.98	7.05-9.35	0.96	0.55	11.44	6.74	8.39	8.16	1.53
Dry matter content (%)	7.38-10.29	7.26-8.06	1.15	0.73	13.04	9.73	8.82	7.50	7.25*
Iron content (mg/100 g)	0.63-0.96	0.76-0.93	0.07	0.35	8.74	7.17	0.87	0.83	3.73*
Phenol content (mg/100 g)	16.87-41.97	23.50-40.61	2.38	1.75	6.87	5.21	34.63	33.59	1.61
Bacterial wilt incidence (%)	2.67-13.45	4.39-18.61	2.35	1.47	27.93	13.16	8.41	11.17	-10.53*

* Significant at $P < 0.05$.

progenies could be attributed to accumulation of favourable genes in positive direction. As regards the range in mean values for the various characters, it was observed that the lower value of the range was less in BIPs compared to F_3 progenies and the higher value was high in BIP's as compared to F_3 progenies in most of the cases. Obviously, the proportion of desirable variants increased in the BIP's, which was also accompanied by an increase in the mean performance. The analysis of variance indicated the significant differences among the BIP's and F_3 progenies for all the characters studied exhibiting the presence of good quantum of variability between BIPs and F_3 progenies (Tables 2 and 3).

This may be due to more heterozygosity in biparental progenies. The superior performance of biparental families seems to be primarily due to generation of more genetic variability by breakage of both coupling and repulsion phase linkages that conceal the genetic variability in F_2. As such, the study confirms the findings of Kumar (1997) in eggplant, Sharma and Kalia (1998) in garden pea, Kanwar *et al.* (2002) in cauliflower, Kaur and Thakur (2007) in eggplant who had also observed an increase in the mean performance of biparental progenies over F_3 generation. Superior mean performance of BIPs over F_2 selfs would generally be expected when major portion of total genetic variance is additive and additive x additive type. In addition, even dominance and epistatic components could play some role towards increase in the mean of BIPs as compared to F_2 selfs. These results corroborate with the findings of Kanwar *et al.* (2002), Chand *et al.* (1984) in cauliflower, in eggplant (Kumar, 1997; Kaur and Thakur, 2006), and garden pea (Sharma and Kalia, 1998).

The comparison of biparental and F_3 progenies for fruit yield per plant revealed that the mean of BIP's (0.95 kg) was significantly higher than F_3 progenies (0.83 kg). Significantly higher mean values were observed in case BIP's for all the characters under study. The phenotypic variability as revealed by the coefficient of variation (%) was greater in BIP progenies than F_3 progenies for most of the characters. This may be due to the breakage of both coupling and repulsion phase linkage in BIPs. The superiority of BIPs progenies over F_3 progenies with respect to coefficient of variation has also been reported by Singh and Sharma (1983) and Guddadamath *et al.* (2011) in okra. However, exceptions were noted for days to first flowering, fruit length and fruit diameter where the coefficient of variation was higher in F_3 progenies than BIPs. These results substantiated the findings of Dadlani *et al.* (1983), Chand *et al.* (1984) and Kanwar *et al.* (2002), who had also reported superiority of F_3 progenies over BIP's with respect to coefficient of variation.

The genetic analysis of the biparental progenies indicated the presence of greater dominance genetic variance for most of the traits except plant height and branches per plant. However, additive component of genetic variance was found to be of higher magnitude in case of fruits per plant and average fruit diameter. The average degree of dominance was in the over-dominance range for most of the characters. Dharmegowda (1977) and Dixit *et al.* (1984) observed that both additive and non-additive genetic variance were almost equally important for yield and its component traits in brinjal. The heritability estimates were found to be low to high (Table 4).

In inter-varietal cross Arka Keshav × Bhola Nath (AK ×BN), the BIP's $M_2 \times F_6$, $M_2 \times F_{23}$, $M_4 \times F_{30}$, $M_1 \times F_{34}$, $M_2 \times F_{38}$, $M_3 \times F_{41}$ and $M_4 \times F_{45}$ showed high mean values for fruit yield, quality traits and yield contributing components. The outstanding combinations were $M_4 \times F_{45}$, $M_2 \times F_{38}$ and $M_2 \times F_{23}$ which recorded increase in marketable fruit yield to the tune of 46.75, 27.27, 24.68%, 79.36, 55.55, 52.38% and 31.39, 13.95, 11.62% over the parents, Arka Keshav (AK), Bhola Nath (BN) and the F_1 produced from them respectively. These outstanding combinations also showed 39.51, 20.99, 18.52% and 20.21, 4.26, 2.13% increase over F_2 and F_3 generations respectively.

Correlation analysis indicates the association pattern of the component traits with marketable fruit yield. It simply represents the overall influence of particular trait on target traits without revealing the cause and effect relationship. The knowledge of direct and indirect influence of yield contributing characters is of prime importance in selecting high yielding genotypes. In case of BIPs,

Table 2. Analysis of variance for various traits in F_3 progenies of the cross Arka Keshav x Bhola Nath (AK x BN).

Source	df	Mean Squares															
		Marketable yield / plant	Days to fifty percent flowering	Days to first picking	Number of marketable fruits per plant	Fruit length	Fruit diameter	Average fruit dia-meter	Plant height	Number of branches per plant	Fruit weight	Pedicel length	Total soluble solids	Dry matter content	Iron content	Phenol content	Bacterial wilt incidence
Sets	2	0.41	97.05	82.79	21.29	21.02	10.88	10.08	690.80	2.15	206.11	0.23	2.02	0.63	0.004	188.81	98.18
Replication in sets	6	0.001	0.83	3.86	0.12	1.71	0.13	0.17	13.64	0.38	6.90	0.39	0.12	0.90	0.001	24.40	1.36
F_3 progenies in sets	57	0.49*	16.56*	24.08*	3.23*	5.66*	0.58*	0.56*	66.92*	1.22*	23.74*	0.41*	0.62*	0.87*	0.24*	64.95*	9.31*
Remainder among plots	114	0.002	3.74	4.68	1.12	1.69	0.23	0.23	17.18	0.31	5.48	0.17	0.31	0.52	0.002	15.68	2.17
Total	179																

Table 3. Analysis of variance for various traits in biparental progenies of the cross Arka Keshav x Bhola Nath (AK x BN).

Source	df	Mean Squares															
		Marketable yield / plant	Days to fifty percent flowering	Days to first picking	Number of markaetable fruits per plant	Fruit length	Fruit dia-meter	Average fruit dia-meter	Plant height	Number of branches per plant	Fruit weight	Pedicel length	Total soluble solids	Dry matter content	Iron content	Phenol content	Bacterial wilt incidence
Sets	2	0.02	101.01	188.47	46.91	9.33	0.01	0.38	117.45	3.98	276.07	0.51	1.08	3.33	0.35	394.24	36.69
Replication in sets	6	0.01	1.85	8.71	1.52	0.87	0.19	0.26	12.42	0.55	4.66	2.32*	0.24	0.89	0.01	6.58	2.88
BIP's in sets	45	0.02*	52.22*	70.48*	29.73*	11.04*	1.07*	0.95*	91.72*	1.12*	65.77*	1.12*	0.62*	0.90*	1.02*	109.17*	20.46*
Males in sets	9	0.02*	88.21*	133.72*	51.05*	17.65*	1.22*	1.32*	116.68*	1.39*	51.76*	1.39*	0.61*	1.91*	0.32*	198.55*	44.35*
Females in males in sets	36	0.01*	43.22*	54.67*	33.65*	9.39*	1.03*	0.86*	85.48*	1.04*	69.28*	1.05*	1.04*	0.65*	0.98*	86.82*	14.48*
Remainder among plots	90	0.09	1.79	3.86	0.76	0.56	0.24	0.14	6.27	0.76	5.02	0.80	0.87	1.36	0.00	5.74	1.44
Total	143																

* Significant at $P < 0.05$.

Table 4. Estimates of direct and indirect effects at the phenotypic level in biparental and F_3 progenies of cross Arka Keshav x Bhola Nath (AK x BN).

Characters	Populations	DFF	DTFP	MFPP	FL	FD	AFD	PH	BPP	FW	PL	TSS	BWI	DMC	IC	PC	Correlation Coefficient with marketable fruit yield per plant
DFF	BIP	-0.051	0.041	-0.030	0.009	0.015	0.012	-0.030	0.019	0.034	0.001	0.001	-0.017	0.011	0.006	0.009	-0.132
	F3	-0.093	0.045	-0.018	-0.015	0.007	0.017	0.019	0.016	-0.018	-0.008	-0.014	0.013	-0.005	-0.093	-0.015	-0.419*
DTFP	BIP	-0.042	0.053	-0.029	-0.028	0.011	-0.009	0.028	0.019	-0.031	0.006	-0.003	0.016	-0.005	-0.065	-0.012	0.094
	F3	0.004	-0.113	0.075	0.009	0.004	0.015	0.037	0.006	0.038	0.013	0.021	-0.062	0.012	0.012	0.006	-0.152
MFPP	BIP	-0.175	0.097	0.330	-0.022	0.012	0.013	0.121	0.013	0.249	-0.034	0.003	0.011	-0.006	-0.048	-0.009	0.794*
	F3	-0.124	-0.021	0.269	-0.058	0.052	0.040	0.206	0.095	0.246	0.029	0.032	-0.057	0.017	0.025	0.008	0.658*
FL	BIP	0.078	0.073	0.182	0.290	0.066	0.075	0.083	0.057	0.075	0.001	0.020	-0.035	0.033	0.036	0.013	0.199
	F3	0.019	0.010	0.092	0.112	0.042	0.017	0.088	0.029	0.099	0.078	0.017	-0.060	0.163	0.011	-0.016	0.146
FD	BIP	0.071	-0.049	0.076	0.015	0.245	0.095	0.109	0.018	0.052	0.012	0.042	-0.028	0.058	0.031	0.017	0.256
	F3	-0.055	-0.014	-0.028	-0.064	0.017	0.045	-0.026	0.019	0.029	-0.014	-0.021	0.012	-0.007	-0.144	-0.048	0.123
AFD	BIP	0.003	-0.060	0.012	-0.073	-0.179	0.126	0.015	-0.067	0.075	0.006	-0.137	0.073	-0.092	-0.052	-0.018	0.157
	F3	0.001	0.051	0.095	-0.024	0.016	0.043	0.092	0.068	0.085	0.051	0.071	-0.087	0.026	0.018	-0.028	0.122
PH	BIP	0.053	0.048	0.097	0.103	0.116	0.107	0.309	0.094	0.192	0.002	0.013	-0.105	0.084	0.056	0.005	0.662*
	F3	0.012	0.038	0.106	0.097	0.035	0.014	0.213	0.057	0.137	0.039	0.058	-0.094	0.031	0.019	0.020	0.629*
BPP	BIP	0.023	0.023	0.027	0.026	0.009	0.013	-0.013	0.063	0.022	0.002	0.010	-0.008	-0.016	0.008	0.009	0.094
	F3	0.001	0.024	0.037	-0.003	0.011	0.001	0.036	-0.072	0.001	0.027	0.024	-0.024	0.029	0.012	-0.027	0.253
FW	BIP	-0.114	0.092	0.148	0.112	0.036	0.039	0.103	0.060	0.471	0.005	0.009	-0.054	0.031	0.035	0.014	0.881*
	F3	-0.232	-0.032	0.112	0.102	0.049	0.051	0.094	0.053	0.394	0.035	0.042	-0.079	0.023	0.037	0.030	0.725*
PL	BIP	0.001	-0.044	-0.004	0.003	0.006	-0.007	-0.002	-0.001	-0.001	-0.029	0.002	0.004	-0.002	0.001	-0.001	0.007
	F3	0.013	0.001	0.037	0.006	0.007	0.007	0.002	0.001	0.002	0.086	0.023	-0.055	0.014	0.022	0.004	0.216
TSS	BIP	-0.003	-0.025	-0.010	-0.015	-0.003	-0.002	0.005	0.007	0.006	0.006	0.075	-0.000	-0.021	-0.007	-0.005	-0.088
	F3	0.002	0.007	0.012	0.007	0.001	0.009	0.007	0.003	0.004	0.025	0.091	-0.020	0.026	-0.037	-0.008	0.107
BWI	BIP	0.000	0.058	0.002	-0.001	-0.002	-0.004	-0.001	0.005	0.002	0.002	-0.001	-0.194	-0.017	-0.013	-0.007	-0.495*
	F3	-0.051	0.001	0.001	-0.002	-0.012	-0.023	-0.004	-0.002	0.002	0.015	0.019	-0.107	-0.016	0.011	-0.001	-0.503*
DMC	BIP	0.000	0.015	0.000	0.003	0.003	0.007	0.003	0.003	0.006	0.008	0.001	-0.013	0.140	0.022	-0.016	0.201
	F3	0.003	0.004	0.039	0.003	0.005	0.006	0.001	0.004	0.008	0.006	0.010	-0.006	0.035	0.013	0.007	0.178
IC	BIP	0.005	-0.013	0.001	0.002	0.002	0.000	0.001	0.001	0.006	0.003	0.009	-0.008	0.019	0.126	0.006	0.209
	F3	0.000	0.001	0.023	0.003	0.002	0.002	0.003	0.003	0.003	0.002	0.002	-0.001	0.003	0.007	0.002	-0.133
PC	BIP	0.002	0.002	0.003	-0.003	-0.003	-0.003	0.004	0.001	-0.003	0.000	-0.001	-0.005	0.201	0.209	-0.019	0.031
	F3	0.002	0.001	-0.004	-0.002	-0.023	-0.011	0.006	0.002	0.001	-0.003	-0.019	-0.028	-0.012	-0.025	-0.060	-0.196
Residual effect									BIP: 0.0048, F3: 0.0062								

* Significant at 5% level, DFF: Days to 50% flowering, DFP: Days to first picking, MFPP: Number of marketable fruits per plant, FL: Fruit length, FD: Fruit diameter, AFD: Average fruit diameter, PH: Plant height, BPP: Number of branches per plant, FW: Fruit weight, PL: Pedicel length, TSS: Total soluble solids, BWI: Bacterial wilt incidence, DMC: Dry matter content, IC: Iron content, PC: Phenol content.

marketable fruit yield per plant showed significant and positive correlation with number of marketable fruits per plant, plant height and fruit weight whereas it was negatively and significantly associated with bacterial wilt incidence. Chattopadhyay *et al.* (2011), Karak *et al.* (2012), Nayak and Nagre (2013) and Lakshmi *et al.* (2014) have also recorded similar results in brinjal. Among the component characters, days to 50% flowering had positive and significant association with days to first picking, fruits per plant, whereas it was negatively correlated with bacterial wilt incidence. Number of marketable fruits per plant had a positive and significant association with plant height and number of branches per plant and non-significantly negative correlation with bacterial wilt incidence. Fruit length showed no significant correlation with any other character in cross AK × BN. The fruit diameter was positively correlated with fruit weight and manifested negative and significant association with total soluble solids. The average fruit diameter was positively correlated with fruit weight and negatively and significantly correlated with dry matter content. Plant height was positively and significantly correlated with fruit weight, while it manifested negative correlation with branches per plant in cross AK × BN. The fruit weight was positively and significantly correlated with total soluble solids, while it manifested positive correlation with dry matter content in cross AK × BN. The fruit weight also exhibited non-significant and negative correlation with bacterial wilt incidence.

In F_3 progenies, marketable fruit yield per plant was significantly and positively correlated with number of marketable fruits per plant and fruit weight in cross Arka Keshav × Bhola Nath, whereas it was negatively and significantly associated with days to 50% flowering and bacterial wilt incidence. Among the component characters, days to 50% flowering manifested positive association with days to first picking, number of marketable fruits per plant, whereas it was negatively correlated with bacterial wilt incidence. Numbers of marketable fruits per plant were positively and significantly associated with plant height, fruit weight in cross Arka Keshav × Bhola Nath, whereas it was negatively correlated with bacterial wilt incidence. Fruit length was significantly and positively correlated with plant height and fruit weight and negative and non-significant association was observed with number of branches per plant. The fruit diameter was positively correlated with average fruit diameter and fruit weight. The average fruit diameter was positively correlated with fruit weight and negatively and significantly correlated with dry matter content. Positive and significant correlation of plant height with fruit weight was observed. The fruit weight was positively and significantly correlated with total soluble solids and dry matter content in cross AK × BN. The fruit weight also exhibited non-significant and negative correlations with bacterial wilt incidence.

Total association between a pair of characters is measured by the correlation coefficients. But the association between the two characters comprises of a complicated pathway involving various other attributes, which may have direct or indirect effects on the dependent characters. Direct contribution of the component characters to fruit weight and the indirect effects, which there may have through their relationship with each other been isolated out through path analysis (Table 5). While comparing the BIP's and F_3 families with respect to the direct effects of the component characters, it was observed that best expression of the effect in respect of fruit weight was obtained in BIP's and F_3 progenies. A perusal of the indirect effect of various component characters on marketable fruit yield per plant indicated that fruit weight via number of marketable fruits per plant, fruit length and plant height contributed the maximum in biparental and F_3 progenies. Fruit weight had the highest direct effects in the BIP's and F_3 progenies. Number of marketable fruits per plant, as well as plant height also contributed substantially indirectly through fruit weight for BIP's and F_3 progenies. Similar observations have also been recorded by Tripathi *et al.* (2009) and Kumar *et al.* (2013) in brinjal.

The number of marketable fruits per plant and plant height contributed to the marketable fruit yield per plant via fruit weight, whereas in case of fruit weight, direct effects were the maximum in the BIPs and F_3

Table 5. Estimates of heritability, predicted genetic gain, variances due to male and females, additive and dominant variances and average degree of dominance for various characters in cross Arka Keshav x Bhola Nath (AK x BN).

Characters	σ^2m	σ^2f	σ^2A	σ^2D	Average degree of dominance	Heritability in narrow sense (%)	Predicted genetic gains from one cycle of selection	
							Full-sib family selection (% of mean)	Mass selection (% of mean)
Marketable fruit yield/plant (kg)	0.01 ± 0.03	0.02* ± 0.01	0.041 ± 0.03	0.063* ± 0.06	1.24	8.54	4.04	2.03
Days to 50% flowering	3.75 ± 3.24	13.81* ± 3.31	14.99 ± 12.96	40.24* ± 18.52	1.64	15.87	3.68	1.59
Days to first picking	6.59 ± 4.86	16.94* ± 4.18	26.35 ± 19.46	41.39* ± 25.66	1.25	7.10	0.58	0.19
Number of marketable fruits per plant	3.59 ± 0.40	6.52* ± 0.74	14.37* ± 1.60	11.72 ± 3.36	0.90	52.27	4.08	1.07
Fruit length (cm)	0.69 ± 0.65	2.95* ± 0.71	2.75 ± 2.60	9.02* ± 3.88	1.81	20.75	3.48	1.43
Fruit diameter(cm)	0.02 ± 0.04	0.27* ± 0.07	0.06 ± 0.19	0.99* ± 0.37	4.06	25.21	6.12	2.10
Average fruit diameter (cm)	0.20* ± 0.04	0.24* ± 0.06	0.79* ± 0.33	0.15 ± 0.13	0.44	35.73	4.30	2.27
Plant height (cm)	23.80* ± 4.45	26.40* ± 6.54	95.20* ± 31.67	10.40* ± 9.82	0.33	66.35	5.98	1.88
Number of branches per plant	0.11* ± 0.02	0.15 ± 0.08	0.49* ± 0.09	0.16 ± 0.21	0.57	30.56	8.31	3.16
Fruit weight (g)	1.46 ± 1.26	24.34* ± 5.30	5.84 ± 4.06	91.51* ± 23.07	3.96	15.82	3.81	1.35
Pedicel length (cm)	0.03 ± 0.02	0.09 ± 0.08	0.11 ± 0.10	0.22 ± 0.21	1.41	7.56	2.31	1.16
Total soluble solids (%)	0.00 ± 0.02	-0.14* ± 0.06	-0.00 ± 0.09	-0.56 ± 0.29	*	*	*	*
Dry matter content (%)	0.10 ± 0.06	-0.24* ± 0.08	0.42 ± 0.27	-1.37* ± 0.43	*	*	*	*
Iron content (mg/100 g)	0.001 ± 0.00	0.006* ± 0.001	0.005 ± 0.002	0.014* ± 0.005	1.67	26.03	0.82	0.21
Phenol content (mg/100 g)	9.31 ± 7.24	27.03* ± 6.64	37.24 ± 28.99	70.86 ± 39.33	1.38	9.01	6.35	4.10
Bacterial wilt incidence (%)	1.86 ± 1.60	4.35* ± 1.10	7.43 ± 7.08	9.95* ± 6.40	1.16	11.42	7.90	3.71

* Small negative estimate, * Not computed, * Significant at $P < 0.05$.

progenies. Hence, fruit weight appeared to be the most appropriate and rewarding character for the selection to operate for obtaining high fruit yield in brinjal. The varying magnitudes of direct and indirect effects of characters towards marketable fruit yield were noticed in this study. From the foregoing discussion, it has become evident that biparental mating is useful in releasing additional variability in early segregating generations.

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