

## HETEROISIS IN CHILLI (*CAPSICUM ANNUM L.*)

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Although chilli (*Capsicum annum L.*) is a predominantly self pollinated crop, considerable variation is noticed due to cross pollination through the activities of bees. Differences in style length, and proximity between different lines also contribute to outcrossing. Positive heterosis has been reported in chilli as early as 1933 (Despande), but commercial production of hybrids has not yet become popular. Since the first report, positive heterosis for many of the economic characters such as number of fruits, yield as well as nutritive qualities have been observed by many workers. (Pal, 1945; Greenleaf, 1947; Angeli, 1972; Nair and George, 1973; Alpatev and Khrenova, 1976; Popova and Mikhailov, 1976; Novak and Chmela, 1979). However, except for the release of one or two F1 hybrids, conscious effort to evaluate and exploit genetic variability present in this crop for heterosis breeding has been lacking. As breeding for nutritional quality is assuming important in all crops, among the other economically important traits, four nutritional and quality attributes namely vitamin A, vitamin C, capsaicin and oleoresin were examined in the present study. Inbreeding was done for one generation.

### Materials and Methods

Based on phenotypic, genetic, agronomic and adaptive divergence, the following nine parents were chosen for crossing.

- |                |                     |
|----------------|---------------------|
| 1 CA 960       | 6 Pant C1           |
| 2 CA 1068      | 7 Pusa Jwala        |
| 3 G4           | 8 California Wonder |
| 4 Purple Round | 9 Purple Cluster    |
| 5 Vellanotchi  |                     |

The inbreeds were crossed in all possible combinations without reciprocals during the year 1978 at the Department of Agricultural Botany, College of Agriculture, Vellayani. In 1979, nine parents and their thirtysix F1 hybrids were grown together in a randomized block design with three replications. The inter and intra row distances were 75 cm and 45 cm respectively. Each treatment consisted of twenty plants of which ten plants were selected randomly for recording observations. Observations of height, number of primary and secondary branches, number of leaves, spread of the plant, number of days taken for blooming, weight, length, girth, size and number of fruits, number of seeds per fruit, total yield, lifespan, vitamin A, vitamin C, capsaicin and oleoresin content were recorded. The estimation of vitamin A was carried out by the method suggested by Rao *et al.* (1968). Titration method employing 2, 6-dichlorophenol indophenol was used for the estimation of vitamin C. Capsaicin was estimated by using thin layer chromatography followed

by spectrophotometry method as suggested by Mathew *et al.* (1971). Oleoresin was estimated by the method described by Mathew *et al.* (1971). Heterosis over mid-parental value and heterosis over better parent were worked out with respect to eighteen economic attributes. Negative heterosis with respect to number of days taken for blooming and number of seeds per fruit was also worked out.

### Results and Discussion

All the characters under investigation manifested heterosis over the mid-parental values, though there was wide variation for different traits in different cross combinations. Maximum heterosis was noticed in number of primary branches and vitamin C content. As regards the five fruit characters namely, weight, length, girth and size of fruits and number of seeds per fruit, there was very little positive heterosis. Only four crosses displayed positive heterosis for weight of fruit when heterosis was computed over mid-parental value and no heterosis over better parent. As regards length of fruit, only four hybrids exhibited positive heterosis over mid-parental value while none of the crosses showed heterosis over better parent.

A comparison of the average heterosis for the various characters revealed that number of secondary branches topped the list followed by vitamin C, capsaicin content and number of primary branches. When heterosis was computed over mid-parental value, 100 percent significant heterotic crosses were obtained in two traits namely number of primary branches and vitamin C content. The corresponding figures for secondary branches, oleoresin content, lifespan and capsaicin content were 97.3, 97.3, 94.5 and 91.7 respectively. Length of fruit and weight of fruit showed the lowest percentage (11.2 each). The maximum heterosis percentage over mid-parental values namely 1481.94 and 1365.53 were manifested by the characters number of leaves (CA 1068 x Purple Cluster) and total yield (Purple Round x Vellanotchi) respectively. Popova and Mikhailov (1978) reported similar results in red pepper (*Capsicum annum*). They further noticed that the embryos of the hybrid seeds were larger than those of the parents and thereby heterosis became apparent immediately after fertilization. However, Novak and Chmela (1979) recorded heterosis of fifty per cent and above for total yield and attributed the phenomenon to over-dominance.

The maximum heterosis for vitamin C and capsaicin content was displayed by CA 960 x Purple Cluster (498.15 per cent) and Purple Round x California Wonder (980.46 per cent) respectively. An analysis of the performance of hybrids revealed that Purple Round x Vellanotchi (4 x 5) was the best with respect to number of fruits, total yield and lifespan. It is interesting to note that the same hybrids was the most heterotic for number, girth and size of fruits, total yield and oleoresin content. The mean number of fruits and total yield per plant were 334 and 1443.8 g respectively. This hybrid was also endowed with other desirable attributes like high vitamin A (6761 I. U.) vitamin C (307.6 mg%) and capsaicin (0.897%) content.

Table 1  
Mean values in parents and F<sub>1</sub> hybrids and heterosis

Characters	Parents	F <sub>1</sub>	Average heterosis (percentage)	Best performing F <sub>1</sub>	Most heterotic F <sub>1</sub>	Percentage of significantly heterotic crosses	
						Over mid-parental value	Over better parent
Height of plant (cm)	46.48	48.62	4.59	4 x 6	4 x 6	30.0	30.6
Number of primary branches	5.36	9.90	84.49	4 x 6	1 x 2	100.0	97.3
Number of secondary branches	25.64	62.75	144.76	2 x 5	4 x 6	97.3	86.2
Number of leaves	3172.93	4341.09	36.81	2 x 4	2 x 4	2.8	2.8
Spread of plant (cm)	38.20	52.76	38.13	4 x 6	4 x 6	80.6	72.3
Number of days taken for blooming	79.56	79.92	0.46	2 x 4	2 x 8	36.2	19.5
Number of fruits	48.68	85.20	75.02	4 x 5	4 x 5	72.3	58.4
Weight of fruit (g)	5.83	2.98	—	—	5 x 8	11.2	—
Length of fruit (cm)	6.96	5.36	—	—	5 x 9	11.2	—
Girth of fruit (cm)	5.80	4.62	—	—	4 x 5	13.9	5.6
Size of the fruit (cm <sup>3</sup> )	6.17	4.38	—	—	4 x 5	13.9	11.2
Number of seeds per fruit	66.75	46.94	—	—	3 x 9	13.9	5.6
Total yield (g)	111.68	201.45	80.36	4 x 5	4 x 5	38.9	19.5
Lifespan (days)	142.76	189.62	32.82	4 x 5	2 x 8	94.5	94.5
Vitamin A (I. U)	6568.27	5018.91	—	—	2 x 7	—	—
Vitamin C (mg%)	108.80	251.41	131.07	5 x 8	1 x 9	100.0	94.5
Capsaicin (percentage)	0.24	0.55	129.75	6 x 7	4 x 8	9.7	61.2
Oleoresin (percentage)	7.40	10.30	45.00	1 x 7	4 x 5	97.3	52.8

Table 2

The mean values of parents and F<sub>1</sub> hybrids and their negative heterosis in percentage

Parents and hybrids	Number of days taken for blooming			Number of seeds/fruit		
	Mean	Heterosis per cent over mid-parental value	Heterosis per cent over better parent	Mean	Heterosis per cent over midparental value	Heterosis per cent over better parent
1	2	3	4	5	6	7
1	87.6	—	—	92.2	—	—
2	74.3	—	—	57.2	—	—
3	87.1	—	—	46.0	—	—
4	97.1	—	—	23.2	—	—
5	74.4	—	—	100.1	—	—
6	78.3	—	—	45.2	—	—
7	83.4	—	—	51.1	—	—
8	58.4	—	—	157.9	—	—
9	75.4	—	—	27.8	—	—
1 x 2	83.3	—	4.794**	50.4	32.530**	45.336**
1 x 3	88.0	—	—	50.1	27.496**	45.661**
1 x 4	92.3	—	4.943**	20.9	63.778**	77.332**
1 x 5	74.2	8.395**	15.296**	130.7	—	—
1 x 6	75.5	8.981**	13.812**	60.3	12.227**	34.598**
1 x 7	83.7	2.105**	4.452**	50.1	30.076**	45.662**
1 x 8	83.8	—	4.337**	101.2	19.072**	35.908**
1 x 9	79.0	3.067**	9.817**	38.6	35.700**	58.134**
2 x 3	80.6	0.123	7.462**	24.4	52.713**	57.342**
2 x 4	100.1	—	—	14.6	63.681**	74.475**
2 x 5	80.7	—	—	91.1	—	8.991**
2 x 6	92.3	—	—	47.0	8.203**	17.832**
2 x 7	92.0	—	—	38.1	29.639**	33.391**
2 x 8	86.7	—	—	87.6	18.549**	44.522**
2 x 9	75.5	—	—	30.3	29.203**	47.027**
3 x 4	88.1	4.343**	9.268**	12.1	65.028**	73.695**
3 x 5	81.4	—	6.544**	64.8	11.293**	35.265**
3 x 6	79.9	3.385**	8.266**	31.9	30.043**	30.652**
3 x 7	75.4	11.554**	13.432**	44.9	7.518**	12.133**
3 x 8	68.7	5.567**	21.135**	52.2	48.798**	66.941**
3 x 9	83.1	—	4.592**	53.6	—	—

(Table 2 continued)

	1	2	3	4	5	6	7
4 x 5	76.9	10.320**	20.803**	26.7	56.690**	73.326**	
4 x 6	75.3	14.139**	22.451**	17.0	48.338**	61.061**	
4 x 7	86.6	4.044**	10.813**	17.1	53.970**	66.536**	
4 x 8	69.1	11.125**	28.836**	31.4	65.323**	80.114**	
4 x 9	88.8	—	8.547**	10.4	59.215**	62.589**	
5 x 6	79.3	—	—	36.4	49.896**	63.636**	
5 x 7	77.5	1.774**	7.074**	86.4	—	13.686**	
5 x 8	66.0	0.602	11.290**	99.5	22.868**	36.985**	
5 x 9	83.1	—	—	30.2	92.775**	69.830**	
6 x 7	76.7	5.132**	8.033**	32.6	32.294**	36.203**	
6 x 8	69.8	—	10.855	45.4	55.292**	71.248**	
6 x 9	75.6	1.626*	3.448**	44.2	—	2.212	
7 x 8	62.4	11.988**	25.179**	50.8	51.387**	67.827**	
7 x 9	91.3	—	—	37.4	5.196**	26.810**	
8 x 9	54.6	18.385**	27.586**	28.6	69.197**	81.887**	
CD (0.05)		1.341	1.549		2.139	2.470	
CD (0.01)		1.771	2.052		2.833	3.272	

\*\* Significant at 1% level

The mean number of seeds per fruit in the hybrid was only 26.7 which was an added advantage. The rind of the fruit was thick and as such ideally suited as a fresh vegetable. An examination of general combining abilities revealed that Purple Round was the best general combiner for height, number of primary branches, spread and lifespan in addition to being the second best general combiner for total yield, number of fruits and number of leaves. Vellanotchi, the second parent involved in the cross exhibited the highest general combining ability for total yield. Further, it was the second best general combiner for weight, girth and size of fruit and vitamin C content. As regards vitamin C content, Vellanotchi x California Wonder (5 x 8) was the best hybrid. This was also the most heterotic hybrid for weight of fruit.

Another promising hybrid was Pant C1 x Purple Cluster. The mean number of fruits was 142.8. Since both parents had erect fruit habit, the hybrid also produced erect fruits, which enabled uniform maturity and early ripening. This hybrid had also reasonable quantities of vitamin A, vitamin C, capsaicin and oleoresin. Table 1 represents the overall mean values for parents and F1 's, average heterosis and percentage of significantly heterotic crosses. The best performing F1 and the most heterotic F1 were also identified with respect to different characters studied.

Negative heterosis was manifested in two important economic attributes namely number of days taken for blooming and number of seeds per fruit. The percentages of negative heterosis computed over mid-parental values and better parent are presented in Table 2. California Wonder x Purple Cluster (8 x 9) displayed maximum negative heterosis for number of days taken for blooming, besides being the most heterotic F<sub>1</sub> for the character concerned as well as the number of seeds per fruit when computed over mid-parental value. The hybrid Purple Round x Purple Cluster (4 x 9) manifested maximum negative heterosis for the number of seeds per fruit.

In general, very little expression of hybrid vigour in vitamin A content was displayed. Only two hybrids (2 x 7 and 4 x 5) exceeded their better parents, as far as this trait was concerned. But there was considerable manifestation of hybrid vigour in vitamin C and oleoresin content. Out of the 36 hybrid combinations all hybrids transgressed their better parents except one (1 x 4). Nineteen hybrids manifested hybrid vigour for oleoresin content. The lower capsaicin content in hybrids might be due to the higher vitamin C content. Such inverse relationship was earlier reported by Nair and George (1973). The apparent reduction of vitamin A in hybrids can be ascribed to the higher pungency as suggested by Lee *et al.* (1973). The very low increase in carotene in hybrids was in agreement with the observations of Buezak *et al.* (1970). An examination of the results indicated that the best performing F<sub>1</sub>'s were not always the most heterotic ones as reported by Balachandran (1978) in tomatoes. The results however, revealed that in many instances one or both the parents of the best performing F<sub>1</sub>'s had the highest general combining ability for the character under consideration.

### Summary

An experiment was laid out in 1979 at the Department of Agricultural Botany, College of Agriculture, Vellayani to study the heterosis in *Capsicum annum* L. Nine parents and 36 F<sub>1</sub> hybrids were compared. Eighteen economic attributes including vitamin A, vitamin C, capsaicin and oleoresin content were studied. All the characters under investigation manifested heterosis over mid-parental values though there was wide variation for different traits in different cross combinations. Maximum heterosis was noticed for number of primary bradches and vitamin C content. A comparison of average heterosis for various characters revealed that number of secondary branches topped the list followed by vitamin C, capsaicin content and number of primary branches. The studies identified two promising hybrids with desirable attributes namely Purple Round x Vellanotchi and Pant C1 x Purple Cluster. Negative heterosis was noticed for two important economic attributes namely number of days taken for blooming and number of seeds per fruit. For nutritive and quality characters very little expression of hybrid vigour in vitamin A content was noticed. However, there was considerable manifestation of hybrid vigour in vitamin C and oleoresin content.

സംഗ്രഹം

കാപ്സികം ആനം വർഗ്ഗത്തിൽപ്പെട്ട മുളകുകളുടെ സങ്കരസ്വഭാവത്തെപ്പറ്റി പഠിച്ചുകൊണ്ട് 1979 ൽ വെള്ളായണി കാർഷിക കോളേജിലെ ബോട്ടണി ഡിപ്പാർട്ട്മെന്റിൽ ഒരു പരീക്ഷണം നടത്തുകയുണ്ടായി. ഒൻപത് വ്യത്യസ്ത ഇനങ്ങളും അവയുടെ മുപ്പത്തി ആറ് സങ്കരസന്തതികളും തമ്മിലുള്ള താരതമ്യ പഠനമാണ് നടത്തിയത്. കാപ്സെയിസിൻ, ഓളിയോ റെസിൻ, ജീവകം ഏ, ജീവകം സി എന്നിവ ഉൾപ്പെട്ട പതിനെട്ട് വിളംബകങ്ങളാണ് നിരീക്ഷണത്തിന് വിധേയമാക്കിയത്. എല്ലാവിളംബകങ്ങളും സങ്കരസ്വഭാവം വ്യത്യസ്തമായ തോതിൽ പ്രകടിപ്പിച്ചു. ഏറ്റവും കൂടുതൽ സങ്കരസ്വഭാവം പ്രകടമാക്കിയത് ജീവകം ഏ, പ്രാഥമിക ശിഖരം എന്നീ ഘടകങ്ങളാണ്. ശരശരി സങ്കരസ്വഭാവം തമ്മിൽ പരിശോധിച്ചപ്പോൾ ദ്വിതീയ ശിഖരങ്ങൾ, ജീവകം സി, കാപ്സെയിസിൻ, പ്രഥമശിഖരങ്ങൾ എന്നീ മുൻപ്രകാരമാണ് പ്രകടമായിരിക്കുന്നത്. ഈ പഠനം പർപ്പിൾ റബ്ബർ x വെള്ളനൊച്ചി, പാത് സി-1 x പർപ്പിൾ ക്ലസ്റ്റർ എന്നീ രണ്ട് മേന്മയേറിയ സങ്കര ഇനങ്ങളെ വെളിച്ചത്ത് കൊണ്ടുവന്നു. ആദ്യം പുഷ്പിയ്ക്കാൻ എടുത്ത ദിവസം, ഒരു കായിലെ വിത്തുകളുടെ എണ്ണം എന്നീ ഗുണങ്ങളുടെ ന്യൂനഗുണ സങ്കരസ്വഭാവവും പഠന വിധേയമായി. ജീവകം ഏയിൽ കുറഞ്ഞ അനുപാതത്തിലുള്ള സങ്കര സ്വഭാവമാണ് ദർശിയ്ക്കാൻ കഴിഞ്ഞത്. പക്ഷേ ജീവകം സി, ഓളിയോ റെസിൻ എന്നീ ഘടകങ്ങൾ പ്രകടമായ സങ്കരസ്വഭാവം പ്രദർശിപ്പിച്ചു.

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