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Breeding derivatives with desirable traits using chilli (*Capsicum annuum* L.) stocks and popular varieties

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Abstract

In chilli, four agronomically desirable characters viz. compact plant type, cluster fruit character, upright fruit position and destalkness were transferred from three chilli stocks using as male parent to four popular South Indian varieties using as female parent. The genes controlling the above four characters known to be monogenic and recessive in nature were transferred by selfing and screening the backcross progenies. The rate of expression of the genes responsible for the upright fruit position and clusterness were higher than the compact plant type and destalkness. Inheritance pattern of the four characters was studied to confirm the genes transferred from the chilli stocks to the popular varieties.

Key words : breeding, *Capsicum annuum*, inheritance, selfing

Introduction

Capsicum annuum L. is an important spice cum vegetable crop cultivated throughout the world. In India, chilli is grown in an area of 9,15,200 ('000) ha with an annual production of 1,018 ('000) tones (FAO database). Chilli is cultivated in an area of 659.82 ('000) ha and with an annual production of 396.57 ('000) tones in Tamil Nadu. Most of the popular varieties Bhagyalakhsmi (G-4), Kovilpatti (K-2), Madurai-1 (MDU-1) and Coimbatore (CO-2) have erect, pendulous, solitary upright fruits. Moreover, the fruits are strongly attached with the pedicel. Nearly 20% of the total cost of production goes for harvesting alone. Additional labour is also involved to remove the persistent calyx from the harvested fruits. There are particular traits or genes responsible for the fruit characters and strong attachment of the calyx. Transfer of genes responsible for a desirable character, from one variety or genotype to another has been practised in the past in several vegetable crops. In chilli, attempts were made earlier to transfer the characters such as red colour pigments, clusterness, destalkness, upright fruit orientation and pungency through hybridization between the locally available cultivars (Gopalakrishnan 1985; Ahmed *et al.* 1994). Therefore attempts have been made in the present study to develop compact, clustered, upright and destalked chilli fruit types so as to minimize the labour cost involved in harvesting and processing and also to increase the yield due to the incorporation of cluster fruit characters.

Materials and methods

Seeds of four popular chilli varieties namely

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Bhagyalakshmi (G-4), Kovilpatti (K-2), Madurai-1 (MDU-1) and Coimbatore-2 (CO-2) were procured from Tamil Nadu Agricultural University, Coimbatore. The donor parents to contribute desirable genes included three chilli types namely KAU-cluster carrying four specific genes for compactness (*'cpt'*), upright fruit position (*'up'*), clusterness (*cl*), and destalkness (*'dst'*), Kanthari local carrying a single gene for upright fruit position (*'up'*) and Ujwala possessing upright (*'up'*) and clusterness (*'cl'*). All the genes under transfer are found to be recessive in nature (Gopalakrishnan 1985; Ahmed *et al.* 1994). Therefore, these genes transferred by simple backcrossing method followed by selection. All the F_1 hybrids obtained from the crosses were backcrossed with respective recurrent chilli varieties to obtain BC_1 hybrids. Selected BC_1 plants were selfed as well as backcrossed with respective recurrent chilli varieties to produce BC_1F_2 and BC_2 hybrids. Selected BC_1F_2 plants were again backcrossed twice with respective recurrent chilli varieties to produce BC_2 and BC_3 hybrids. Selfing was done in BC_3 to produce BC_3F_2. There were no significant difference observed in the derivatives developed in BC_2F_2 and B_3F_2 population. Therefore, the BC_1F_2 and B_3F_2 were compared and agronomically desirable derivatives were constituted in BC_1F_2 and B_3F_2 generation in the genetic background of four popular chilli varieties. One line from each of the cross combination carrying the desirable characters was constituted both in BC_1F_2 and BC_3F_2 generation (Tables 1 & 2). The quantitative characters were studied in all the constituted lines. The inheritance of morphological characters of the donor parents such as type of branching, fruiting habit, fruit orientation and destalkness were recorded and compared with the constituted lines. Selected lines were crossed with local variety (K-1) carrying erect plant type, pendulous solitary fruit type and strongly stalked pedicel to produce F_1 hybrids. The hybrids were selfed as well as backcrossed with recurrent parent to produce F_2 and BC_2. The F_1 and F_2 and BC_1 populations were evaluated for inheritance of characters. Segregation pattern was recorded and chi-square test was applied.

Results and discussion

Performance of the constituted lines

Among the crosses made, G-4 x KAU-cluster and CO-2 x Ujwala are the good combiners and both upright and cluster fruit character together were inherited in these combinations. The upright fruit character (*'up'*) and clusterness (*'cl'*)

Table 1. Hybrids/plants produced from the crosses between the popular varieties and stocks of chilli

Cross	No. of flowers pollinated	No. of F1 seeds obtained/ No. of F1 hybrids raised	No. of flowers backcrossed in F1 hybrids	No. of BC1 seeds obtained / No. of BC1 plants raised	No. of BC_1F_2 seeds obtained / No. of BC_1F_2 plants raised	No. of plants selected in BC_1F_2
G-4 (Bhagyalakshmi)						
KAU-cluster	50	115/72	50	228/41	236/48	17
Kanthari	50	85/50	30	131/52	155/43	19
Ujwala	50	108/44	25	124/68	212/66	12
K-2 (Kovilpatti-2)						
KAU-cluster	50	98/33	10	135/29	202/96	21
Kanthari	50	117/52	25	234/67	280/85	14
Ujwala	50	79/40	20	201/72	217/78	22
MDU-1 (Madurai-1)						
KAU-cluster	50	28/16	15	114/28	138/47	36
Kanthari	50	33/17	13	105/32	155/64	23
Ujwala	50	101/55	30	134/20	153/58	22
CO-2 (Coimbatore-2)						
KAU-cluster	50	45/18	7	230/61	145/78	13
Kanthari	50	87/27	10	132/58	143/55	21
Ujwala	50	42/30	12	235/77	98/42	18

were found highly effective and expressed more than the genes responsible for compact plant type (*'cpt'*) and destalkness (*'dst'*). All the derivatives produced from the cross CO-2 x Ujwala were expressing upright oval fruit shape as CO-2 parent. Crosses were made in a range of 150-200 flowers from each of the four chilli varieties (G-4, K-2, MDU-1 & Co-2) with stocks (KAU-cluster, Kanthari local & Ujwala) taking the former as female parent and the latter as male parent. The above crossing programme resulted in a total of 799 F_1 hybrids (Table 1). The F_1 seeds were obtained from each crossed fruit. The morphology of the plant type and fruit characters obtained from the crosses between popular cultivars and the stocks carrying specific desirable genes were mostly expressed as intermediate with solitary, semi pendulous fruit type. However, the hybrids obtained from the cross between G-4 and KAU-cluster chilli produced upright, clustered, lengthy fruits with appealing colour. The derivatives obtained from the cross between K-2 x KAU-cluster were compact plant type, pendulous clusters with easy detachment, while MDU-1 x KAU-cluster expressed only compact plant type and easy detachment thereby suppressed the other two characters. However the *'cl'* genes responsible for clusterness did not express in the F_1s of any crosses. The other cross combinations morphologically appeared as the female parent. Desirable F_1 plants were backcrossed to obtain BC_1 generation. A part of BC_1 plants were selfed to get BC_1 F_2 population. Based on the phenotypic expression of the desirable characters, selection was exercised from BC_1F_2 (Table 1) and BC_3F_2 populations (Table 2). All the derivatives from the popular varieties x chilli stocks carrying specific desirable genes expressed either one or all the characters in the field evaluation. However, several constituted lines in BC_3F_2 generation did not express similarity to the recurrent parents, most probably such lines needed few more backcrosses to achieve this state. Pickergill (1997) opinioned that the incorporation of specific desirable genes from the parent to the recipient parent could be achieved only by repeated backcrosses. The advanced backcrosses facilitate the incorporation of genes.

Quantitative characters

A study on quantitative characters revealed that among various lines selected, lines carrying *'cl'* gene particularly in BC_3F_2 showed superior per-

Table 2. Details of the generation raised and number of plants selected for desirable characters in chilli

Parent/hybrid	No. of flowers pollinated in BC_1F_2 plants	No. of BC_2 seeds obtained/ No. of BC_2 plants raised	No. of flowers backcrossed in BC_2 plants	No. of BC_3 seeds obtained/ No. of BC_3 plants raised	No. of BC_3F_2 plants raised/No. of plants selected in BC_3F_2
G-4 (Bhagyalakshmi)					
KAU-cluster	25	120/61	50	188/63	127/11
Kanthari local	36	119/48	25	109/42	112/14
Ujwala	26	97/36	30	260/88	106/13
K-2 (Kovilpatti-2)					
KAU-cluster	50	72/18	25	110/75	49/12
Kanthari local	35	68/30	30	130/52	88/18
Ujwala	55	108/55	50	199/74	121/14
MDU-1 (Madurai-1)					
KAU-cluster	50	90/46	25	245/89	64/12
Kanthari	50	87/42	30	128/51	81/21
Ujwala	45	100/50	30	155/62	122/25
CO-2(Coimbatore-2)					
KAU-cluster	30	97/49	45	164/91	122/31
Kanthari local	30	102/61	50	218/90	131/34
Ujwala	40	78/43	45	176/49	97/11

formance in several agronomic characters. The plants of these lines possessed 4-5 cluster fruits per axil and produced good quality fruits. The lines carrying *'cpt'* gene also showed increased number of primary branches per plant there by enhancing the number of flowers per branch. It is well established that among the various yield-contributing characters the most important yield component in chilli is the number of fruits per plant. Increased number of fruits per plant has been considered as the primary selection criteria for selecting high yielding genotypes in chilli cultivars (Bak *et al.* 1975; Abu-El Fade 1979, Thakur *et al.* 1980). The results were in the expected line since more and more backcrosses restored the original genotype of the recurrent parents. Nevertheless the plants in both BC_1F_2 and BC_3F_2 generations possessed reasonably good agronomically desirable features that were the basis for selection in the present study. In general, agronomic characters recorded in BC_3F_2 generation were found to be superior to those respective recurrent parents. In BC_3F_2 generation the constituted lines showed significant raise in their yield than BC_1F_2 generation and the controls. However, when compared to the constituted lines, increase was observed only in those lines that carry *'cl'* genes. Among the constituted lines, fruit yield was higher in the cross combination of K-2 x KAU cluster (518.1), while in control it was 434.4 (K-2). The cross combination G-4 x KAU cluster (476.1), K-2 x Ujwala (431.4), K-2 x Ujwala (431.4) and CO-2 x KAU-cluster (415.44) were at par with their respective recurrent parents (Table 3).

Selection based on fruit quality

The lines that carry *'up'* gene and clustered gene *'cl'* exhibited good fruit quality in terms of number of fruits plant^{-1}, in BC_3F_2 generation. The selected lines derived from the crosses G-4 x KAU-cluster (Fig.1), K-2 x KAU-cluster (Fig.2) MDU-1 x KAU-cluster and CO-2 x Ujwala (Fig. 3) produced medium sized fruits of good physical quality. In general, the quality of fruits produced in BC_1F_2/ BC_3F_2 populations were not much satisfactory in several cases. The plant height in these lines were comparable with recurrent parents and the lines also had more number of primary branches per plant, increased fruit length, more number of fruits per plant, increased yield etc. These lines showed compact plant types with highly desirable fruit quality of commercial importance. The fruits were deep red in colour and the surface was fine and lustrous. In general, the lines, which produced fruits with commercially good physical quality and desirable agronomic characters coupled with yield characters were selected. The

Table 3. Fruit yield per plant (g) among the parents and constituted lines in chilli

Parent/constituted line	BC_1F_2	BC_3F_2	Mean	SEd	CD (p=0.05)
G-4 (Control)	446.2	446.2	446.2	P=1.498	2.22
G-4 x KAU-cluster	511.0	520.0	515.5	T=2.369	3.51
G-4 x Kanthari local	375.4	382.0	378.7	PxT=3.350	4.97
G-4 x Ujwala	492.3	506.3	476.1		
K-2 (Control)	430.6	430.6	430.6	P=0.623	0.92
K-2 x KAU-cluster	517.0	519.2	518.1	T=0.985	1.46
K-2 x Kanthari local	412.7	414.2	413.4	PxT=1.393	NS
K-2 x Ujwala	439.7	440.4	440.6		
MDU-1 (Control)	412.0	412.0	412.0	P=1.011	1.50
MDU-1 x KAU-cluster	316.0	462.2	473.8	T=1.599	2.37
MDU-1 x Kanthari local	307.0	312.8	309.9	PxT=2.260	3.36
MDU-1 x Ujwala	319.7	485.4	316.8		
CO-2 (Control)	394.0	394.0	394.0	P=0.796	1.18
CO-2 x KAU-cluster	418.0	415.4	412.8	T=1.259	1.87
CO-2 x Kanthari local	322.0	319.7	319.4	PxT=1.750	NS
CO-2 x Ujwala	316.8	338.6	338.0		

Table 4. Conformation of genes through genetical studies (inheritance) in chilli (*Capsicum annuum* L.)

Cross		Observed number of plants							
		Erect, pendulous, solitary, stalked	Upright	Upright, clustered	Compact, upright, clustered, destalked	Total	Genetic ratio	X^2	P
(G-4 x KAU cluster) x K-1	F1	52	-	-	0	52	-	-	-
	F2	281	-	-	92	373	3:1	0.210	0.50-0.70
	BC1	166	-	-	197	363	1:1	0.178	0.30-0.50
(K-2 x Kanthari) x K-1	F1	57	0	-	-	57	-	-	-
	F2	247	76	-	-	323	3:1	0.679	0.70-0.80
	BC1	121	106	-	-	227	1:1	1.071	0.20-0.30
(CO-2 x Ujwala) x K-1	F1	55	-	-	-	55	-	-	-
	F2	188	-	42	-	230	3:1	4.267	0.50-0.10
	BC1	116	-	99	-	215	1:1	1.344	0.20-0.30

observation in the present study also suggests that due to transfer of desirable genes/characters there was no significant depression in the fruit yield or yield contributing characters. However, there are a few reports of yield de-

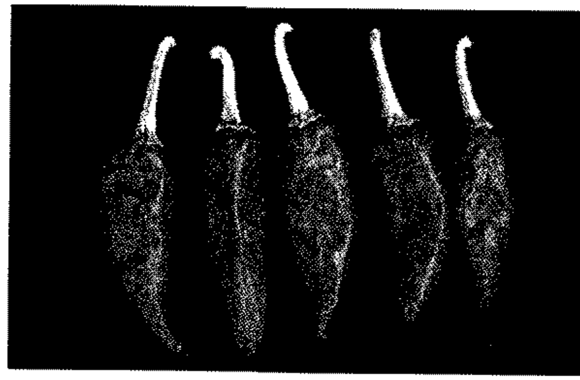

Fig. 1. Fruits of the constituted line (G-4 x KAU-cluster) showing medium sized bright coloured fruits

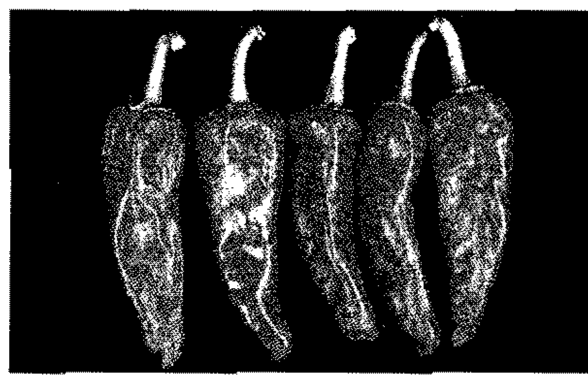

Fig. 2. Fruits of the constituted line (K-2 x KAU-cluster) showing medium sized bright coloured fruits

Fig. 3. Fruits from the cross combination of Co-2 x Ujwala showing upright ('up') oval shaped fruits brone on the periphery region of the plant

pression associated with transfer of genes in other chilli genotypes (Amarchandra *et al.* 1983; Ahmed *et al.* 1985).

Confirmation of transfer of genes

Three constituted lines each one of them carrying the desirable genes either singly or in combination, responsible for four desirable agronomic characters viz. compact plant type, erect fruit position, clusterness and destalkness were crossed with a local variety K-1 using the latter as a male parent. The variety K-1 is characterized with erect plant type, pendulous, solitary stalked fruits. A total of 52 to 57 F_1 hybrids were obtained per each cross combination, one F_1 hybrid was selfed to produce 230 to 373 F_2 plants. The F_2 segregation pattern for respective character was in agreement with a ratio of 3:1 for dominant (K-1) to recessive characters (constituted lines) suggesting the monogenic recessive nature of the gene under transfer (Table 4). The F_1 hybrids were also used in backcrossing with their respective recurrent parents and a total of 215 to 363 BC_1 hybrids were raised from each cross. Nearly half of the BC_1 hybrids expressed the desirable characters of the constituted lines, the segregation pattern of BC_1 showed dominant and recessive characters in 1:1 ratio indicating the successful incorporation of the desirable genes from the donor parents into the popular chilli varieties.

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