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Inter-allelic relationships of S-allele lines in cabbage (*Brassica oleracea* var. *capitata* L.)

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Abstract

Five S-allele lines of cabbage were crossed in a diallel fashion. The F_1s and the corresponding S-allele parental lines were crossed reciprocally in freshly opened flower stage both as female (stigma) and male (pollen) inside the UV stabilized nylon-net insect proof structures. The results were interpreted on the basis of seed-set data obtained. In pollen, majority of the heterozygotes (7) showed partial dominance whereas in stigma, majority of the heterozygotes (7) revealed co-dominance. The S-allele activity in pollen and stigma ranged between 2-100 per cent. Complete dominance of one S-allele over the other S-allele could not be observed. Based on inter-allelic relationships and S-allele activities, it can be concluded that the S-allele lines I-4-6, II-12-4-9 and SC-5-5-4 possess strong S-alleles and hold good promise in hybrid seed production.

Key words: *Brassica oleracea* var. *capitata*, cabbage, S-allele interaction, S-allele activity.

Introduction

Cabbage tops the list of the cole crops in acreage and production in the world. However, in India it ranks next to cauliflower in acreage but higher in production. In Himachal Pradesh, it is being cultivated extensively as an off-season vegetable in mid and high hills. Hybrids are preferred over open pollinated varieties on account of their higher yield, uniform maturity, quality produce and better adaptability under adverse growing conditions. The genetic phenomenon of sporophytic self incompatibility (SSI) has been utilized commercially for the production of hybrids in cabbage for the last over six decades in agriculturally advanced countries (Riggs, 1988). Of late, cabbage hybrid KGMR-1 has been developed at IARI, Regional Station, Katrain by using SSI (Anon. 2005). At CSKHPKV, Palampur, homozygous self incompatible (S-allele) lines have been developed in mild chill requiring genotypes of cabbage. The crossability among the different S-allele parental lines in the production of three-way, four-way and triple cross hybrids depends on their inter-allelic relationships. Generally, the S-allele lines having stronger S-alleles are preferred for hybrid seed production so as to minimize the chances of possible sibs in the hybrid seed. Hence, the present study was undertaken to ascertain the same in five of the elite S-allele lines.

Materials and Methods

The experimental materials consisted of five elite S-allele lines viz., I-

4-3 (P1), I-4-6 (P2), II-12-4-9 (P3), III-1-2 (P4) and SC-5-5-4 (P5) of cabbage developed at CSK, Himachal Pradesh Krishi Vishvavidyalaya, Palampur. During 2006-2007, these S-allele lines were crossed in diallel fashion and F_1 seeds of nine hybrids were obtained. The F_1 between I-4-6 and II-12-4-9 was not attempted as both carried the same S-allele. The S-allele lines and the nine F_1s were raised during 2007-2008. These were covered with UV stabilized nylon net insect proof enclosures. Three plants in each F_1 and the corresponding two S-allele lines were marked for pollination. Each of the three F_1 plants was crossed with each of the three plants in each of two S-allele lines from which the F_1 was developed. Similarly, each of the three plants in the two S-allele lines was crossed with each of the three F_1 plants. The cross-pollinations were made in freshly opened flower stage and for each pollination about 10 such flowers were selected. Some plants of the parental S-allele lines and F_1s were retained in the open to allow for free cross-pollination in nature (NCP). Average seed set/siliqua in different pollinations were recorded and used in interpreting the results. S-allele activities were quantified as per the following procedure adopted by Vidyasagar (1981) and Murugiah *et al.* (1985).

Per cent S-allele activity = (1-S/N) x100, where S is the average number of seeds per siliqua in controlled cross pollination and N is the average number of seeds per siliqua in natural cross-pollination. The S-allele interactions in pollen and stigma were assigned the types as suggested by Thompson (1957).

Results and Discussion

The average seed set per siliqua in crosses and natural cross pollination (NCP) and S-allele activity in pollen using hybrids as male and corresponding S-allele parental lines as female are given in table 1 whereas the average seed set per siliqua in crosses and natural cross pollination and the S-allele activity in stigma using hybrids as female and corresponding S-allele parental lines as male are given in table 2. The relative S-allele activity and the S-allele interaction type in each of the nine (9) S-allele heterozygotes studied are presented in table 3.

In pollen, the S-allele line I-4-3 was recessive to I-4-6, II-12-4-9 and SC-5-5-4 S-allele lines but dominant over III-1-2. It was co-dominant with I-4-6, II-12-4-9 and SC-5-5-4 but dominant over III-1-2 in stigma. The S-allele line I-4-6 was dominant over III-1-2 but co-dominant with SC-5-5-4 in pollen. In stigma, it was co-dominant with both III-1-2 and SC-5-5-4 S-allele lines. The S-allele line II-12-4-9 was dominant over III-1-2 but co-dominant with SC-5-5-4 in pollen. In stigma, it was co-dominant with both III-1-2 and SC-5-5-4. The S-allele line III-1-2 was recessive to the line SC-5-5-4 in pollen as well as in

stigma. Seven heterozygotes *viz.*, (I-4-3 x I-4-6), (I-4-3 x II-12-4-9), (I-4-3 x III-1-2), (I-4-3 x SC-5-5-4), (I-4-6 x III-1-2), (II-12-4-9 x III-1-2) and (III-1-2 x SC-5-5-4) showed partial dominance whereas two heterozygotes *viz.*, (I-4-6 x SC-5-5-4) and (II-12-4-9 x SC-5-5-4) showed co-dominance in pollen. In stigma, two of the heterozygotes *viz.*, (I-4-3 x III-1-2) and (III-1-2 x SC-5-5-4) revealed partial dominance whereas co-dominance of S-alleles was observed in all the remaining seven heterozygotes. This may be attributed to the fact that the S-allele

Table 1. Average seed set/siliqua in crosses and natural cross pollination (NCP) and S-allele activity in pollen using hybrids as male and corresponding S-allele parental lines as female in cabbage

Sr. No.	Heterozygote/homozygote	Average seed-set of the cross (s)	Average seed set under NCP in S-allele lines (N)	S-allele activity in pollen (%)	Degree of dominance (D)
1.	I-4-3 x I-4-6				
	I-4-3	3.46	8.60	60.00	Partial
	I-4-6	1.08	11.80	91.00	dominance
2.	I-4-3 x II-12-4-9				
	I-4-3	5.87	8.60	32.00	- do -
	II-12-4-9	0.05	9.60	99.00	
3.	I-4-3 x III-1-2				
	I-4-3	3.21	8.60	63.00	- do -
	III-1-2	9.52	9.70	2.00	
4.	I-4-3 x SC -5-5-4				
	I-4-3	5.01	8.60	42.00	- do -
	SC-5-5-4	0.51	9.00	94.00	
5.	I-4-6 x III-1-2				
	I-4-6	0.57	11.80	95.00	- do -
	III-1-2	4.32	9.70	55.00	
6.	I-4-6 x SC-5-5-4				Co-
	I-4-6	0.53	11.80	96.00	dominance
	SC-5-5-4	0.23	9.00	97.00	
7.	II-12-4-9 x III-1-2				
	II-12-4-9	0.00	9.60	100.00	Partial
	III-1-2	7.79	9.70	20.00	dominance
8.	II-12-4-9 x SC-5-5-4				
	II-12-4-9	0.00	9.60	100.00	Co-
	SC-5-5-4	2.29	9.00	75.00	dominance
9.	III-1-2 x SC-5-5-4				
	III-1-2	5.48	9.70	43.00	Partial
	SC-5-5-4	1.08	9.00	88.00	dominance

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Table 2. Average seed set/siliqua in crosses and natural cross-pollination (NCP) and the S-allele activity in stigma using hybrids as female and corresponding S-allele parental lines as male in cabbage

Sr. No.	Heterozygote/homozygote	Average seed-set of the cross (s)	Average seed set under NCP in the heterozygote lines	S-allele activity in stigma (%)	Degree of dominance
1.	I-4-3 x I-4-6		1.80		
	I-4-3	0.00		100.00	Co-dominance
	I-4-6	0.00		100.00	
2.	I-4-3 x II-12-4-9		2.60		-- do --
	I-4-3	0.00		100.00	
	II-12-4-9	0.00		100.00	
3.	I-4-3 x III-1-2		8.90		
	I-4-3	0.00		100.00	Partial
	III-1-2	7.41		17.00	dominance
4.	I-4-3 x SC-5-5-4		15.00		
	I-4-3	0.29		98.00	Co-dominance
	SC-5-5-4	0.39		97.00	
5.	I-4-6 x III-1-2		17.80		
	I-4-6	1.18		93.00	-- do --
	III-1-2	2.40		87.00	
6.	I-4-6 x SC-5-5-4		10.60		
	I-4-6	0.31		97.00	-- do --
	SC-5-5-4	0.00		100.00	
7.	II-12-4-9 x III-1-2		5.60		-- do --
	II-12-4-9	0.40		93.00	
	III-1-2	0.36		94.00	
8.	II-12-4-9 x SC-5-5-4		11.10		
	II-12-4-9	0.59		95.00	-- do --
	SC-5-5-4	1.11		90.00	
9.	III-1-2 x SC-5-5-4		13.20		
	III-1-2	5.05		62.00	Partial
	SC-5-5-4	1.41		89.00	dominance

Table 3. Relative S-allele activity and the S-allele interaction type in each of the nine (9) S-allele heterozygotes studied

S. No.	Genotype of the heterozygotes	Activity in percentage		Type of interaction
		In pollen	In stigma	
1.	I-4-3 X I-4-6	P1<P2 60<91	P1=P2 100=100	II
2.	I-4-3 X II-12-4-9	P1<P3 32<99	P1=P3 100=100	II
3.	I-4-3 X III-1-2	P1>P4 63>02	P1>P4 100>17	I
4.	I-4-3 X SC-5-5-4	P1<P5 42<94	P1=P5 98=97	II
5.	I-4-6 X III-1-2	P2>P4 95>55	P2=P4 93=87	II
6.	I-4-6 X SC-5-5-4	P2=P5 96=97	P2=P5 97=100	IV
7.	II-12-4-9 X III-1-2	P3>P4 100>20	P3=P4 93=94	II
8.	II-12-4-9 X SC-5-5-4	P3=P5 100=75	P3=P5 95=90	IV
9.	III-1-2 X SC-5-5-4	P4<P5 43<88	P4<P5 62<89	I

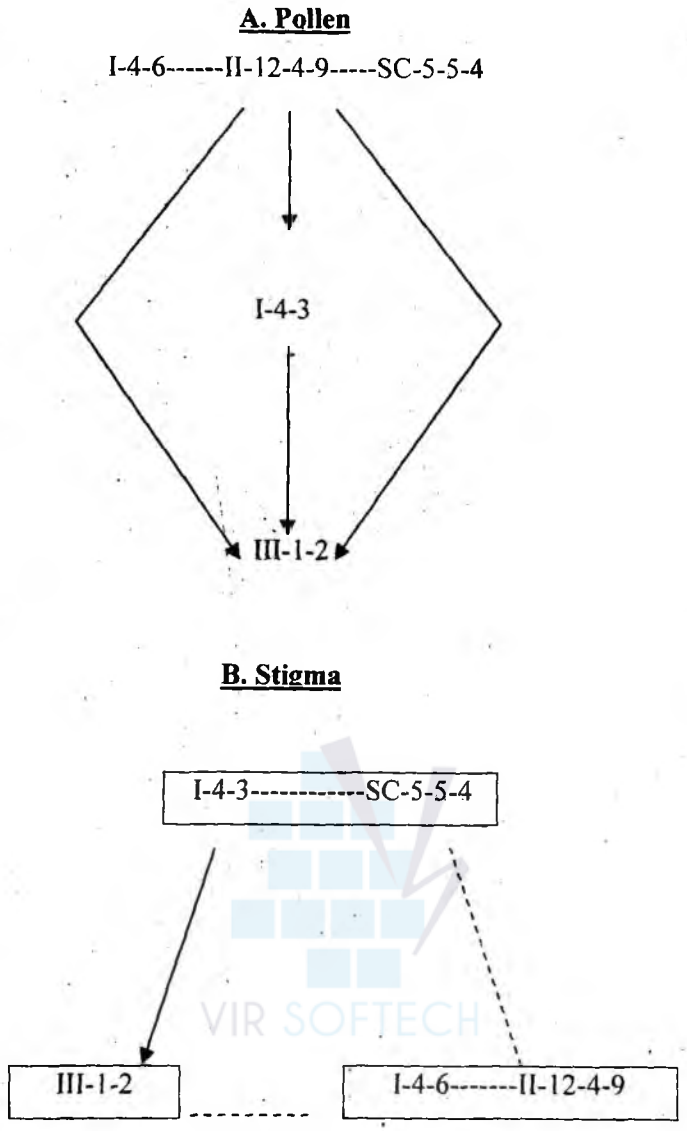
P1=I-4-3; P2=I-4-6; P3=II-12-4-9; P4=III-1-2; P5=SC-5-5-4

activity in the 9 heterozygotes (as male and female) studied, varied from 2 to 100 %. The inter-allelic/dominance relationships among the S-allele lines studied are also illustrated in Fig. 1. Complete dominance of one allele over the other either in pollen or stigma could not be observed in this study. These findings are in consonance with those of Thompson and Taylor (1966), Ockendon (1974 and 1975) and Murugiah (1982).

The type I interaction (dominance of the same S-allele over the other in both pollen and stigma) was observed in two heterozygotes *viz.*, (I-4-3 x III-1-2) and (III-1-2 x SC-5-5-4). The type II interaction (dominance of one S-allele over the other in pollen but co-dominance in stigma) was observed in five heterozygotes *viz.*, (I-4-3 x I-4-6), (I-4-3 x II-12-4-9), (I-4-3 x SC-5-5-4), (I-4-6 x III-1-2) and (II-12-4-9 x III-1-2). The type IV interaction (co-dominance of both S-alleles in pollen as well as stigma) was recorded in two of the heterozygotes viz., (I-4-6 x SC-5-5-4) and (II-12-4-9 x SC-5-5-4). The type III interaction (co-dominance of S-alleles in pollen but dominance of one allele over the other in stigma) was not noticed in any of the heterozygotes studied. These findings are in accordance with those of Murugiah *et.al.* (1985) in Indian cauliflower, who could not detect type III interaction in any of the 25 heterozygotes studied. Hoser-Krauze (1979) reported type III-interaction in only one out of the 18 families studied by her. This implies that the type III S-allele interaction may not be of common occurrence in nature. The S-allele activity in pollen and stigma ranged between 2 to 100 per cent. The activity of the recessive S-allele (III-1-2) in heterozygotes was lower and changed within a wide range of 2-94 per cent as compared to the activity of dominant and co-dominant S-alleles (I-4-6, II-12-4-9 and SC-5-5-4) in which the S-allele activity in both pollen and stigma were not less than 75 per cent and changed within the range of 25 per cent only. This shows that the dominant alleles are strong enough to with stand the possible weakening activity of the recessive S-allele. In general, the activity of the recessive allele was more in the stigma than in the pollen. These findings are in accordance with those of Hoser-Krauze (1979), Wallace (1979) and Murugiah (1982).

Based on inter-allelic relationships and S-allele activities, it can be concluded that the S-allele lines I-4-6, II-12-4-9 and SC-5-5-4 have strong S-alleles whereas the S-allele line III-1-2 has relatively weaker S-allele. The S-allele line I-4-3 ranks in between these two groups.

Fig.1 Inter-allelic relationships among the s-allele lines



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