A STUDY ON CROSSABILITY RELATIONSHIPS IN THE GENUS BRASSICA

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Seven Brassica varieties belonging to five different species were crossed in a diallel fashion to assess crossability relationships among them. The results indicated a varying degree of crossability among these varieties with intra-and inter-varietal combinations yielding greater success than inter-specific matings. There appeared to exist a direct relationship between self-or cross-incompatibility and a slow pollen tube growth.

INTRODUCTION

Very little information on the nature and extent of crossability within oleiferous Brassicae is reported in the literature, though it appears some intra-and inter-specific crosses have been attempted for genetic and cytological studies. According to various reports, (Mohammad *et al* 1931; Akhtar, 1932; Singh, 1958 and Ahmad, 1959) self-incompatibility is quite common in toria, brown sarson and Japan rape. In certain self-fertile types sefilng reduces, while crossing or open-pollination increases, the seed yield as reported by Sun (1937). Rehman (1952) reported that intervarietal matings were highly compatible while most species crossed also among themselves to different extents. Chromosomal imbalance also produces incompatibility or sterility barriers between species. Ahmad (1969) observed that crosses between Brassica species having a different chromosome number were mostly sterile and in some cases showed excessive vegetative growth.

There seems to exist a relationship between the pollen tube growth rate and the extent of self-or cross-compatibilities in plants. In Brassica, however, a few studies have been made on this subject. The pollen tube growth has been studied in situ by tracing it in the styler tissue directly by dissection and indirectly by excision methods by different workers as. for instance, Martin (1913) on *Trifolium pratense* East and Park (1917) on Nicotiana; Kearney and Harrison (1924) on cotton, Brink (1934) on *Melilotus, officinalis* and Stout (1931), Akhtar (1932) and Rehman (1952) on the Brassica.

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A knowledge of this subject could be of great value in assessing the role of allopolyploidy in the evolution of the existing Brassica species and in creating new ones. The present study was therefore undertaken to determine the nature and degree of crossability relationships between, and within the species and if possible, to relate it to the pollen tube growth pattern.

MATERIALS AND METHODS

The seven Brassica varieties included in the study were Toria A, Brown Sarson A, L.G.L. (Brassica Campestris), Yellow Sarson L-1 (Brassica trilocularis), R.L. 16, and RL 18 (Brassica juncea) and D.G.L. (Brassica-napus). These were selfed and intercrossed in all combinations (tabulated). Observations were recorded at maturity on per cent pod-setting, pod length and number of seeds per pod. The following year 49F_1's and 7 selfs were grown in 10-foot long single rows; spaced one foot apart with the same distance between plants within rows. Data were collected on the number of plants emerged, plant height, pod-length and the number of seeds per pod.

The pollen tube growth in vivo was studied by the excision method. The stigmas and styles of the pollinated flowers were removed by excision at the summit of the ovary at successive intervals of 2, 4, 6, 8, 10 and 12 hours after pollination. If after excision a pod with seeds developed, it was assumed that the pollen tube reached the ovary within the specified time and effected fertilization.

RESULTS AND DISCUSSION

The results of these studies indicated a varying degree of crossability among the varieties; generally the percentage of pod and seed setting in intra-and intervarietal combinations was much higher than in the interspecific crosses except for two species, *Brassica campestris* and *Brassica trilocularis.* As may be seen from Table 1, there occurred a great difference in pod-setting, pod-length and the number of seeds per pod as a result of selfing and intra-varietal crossing within the various species. Toria A, BSA, LGL and DGL appeared to be self-sterile since, on selfing, they showed a sharp decrease in per cent pod setting, pod-length and number of seeds per pod as compared to intra-varietal crossing. Other varieties, i.e., RL 16, RL 18 and L-I are self-fertile, yet they showed a tendency to produce relatively reduced pod-and seedset under bag as compared to intra-varietal crosses or open-pollinations. The fact that some of the Brassica varieties like Toria, BSA and DGL are self-sterile and shy seed setters under bag has also been pointed out by Mohammad *et al* (1931), Akhtar (1932), Singh (1958) and Ahmad (1969).

As expected, within a species the varieties were found to be highly crossable as was shown by a high percentage of normal pod and seed set (Table) 2). Also, the varieties belonging to different species were found to intercross to a varying extent (Table 3). Inter-specific crosses between *Brassica campestris* and *Brassica trilocularis*, both having the same chromosome number (2n = 2o) were quite successful and yielded a large amount of pod and seed setting. This compatibility may be ascribed to a greater degree of chromosome homology that may be present between these species. In crosses between other species with different chormosome number the percentage of pod and seed setting was much lower and the majority of the seeds formed were shrivelled and did not germinate (Table 4). Apparently, the difference in the chromosome number appeared to affect the chances of success in crosses between species of this genus, as was also observed by Rehman (1952) and Ahmad (1969) in similar studies.

Wide variation in seedling emergence, plant height and pod and seed setting was observed when selfed and crossed seeds were planted in the field (Table 4). Selfed seeds of the self-sterile varieties mostly failed to germinate, while those of the self-fertile types gave a high percentage of germination and produced normal fertile plants. Seeds obtained from intra-and intervarietal and interspecific crosses involving species with the same number of chromosomes also showed a high percentage of germination, yielding plants with normal height, pod size and seed setting. Hybrid seeds from other interspecific crosses mostly failed to germinate and if at all they did, the percentage of germination was very low; the plants were largely sterile and did not produce pods of normal size with a good number of seeds. Hybrid sterility in some interspecific crosses was also observed by Ahmad (1969) in oleiferous Brassica.

The results of the pollen-tube growth studies in situ are presented in (Table 5). It was observed that in the compatible matings the pollen-tubes traversed the stylar tissue without any difficulty and effected fertilization. But in the self-incompatible matings, the pollen-tubes apparently failed to proceed through the conducting tissue of the style at the right speed, which perhaps was the reason that seed setting in these pollinations did not take place even after an interval of 12 hours. On the other hand, when cross-pollinations were made, the growth of the pollen-tube was quick and resulted in the union of the gametes before the ovules lost their receptivity. In some

TABLE 1. *Percent pod setting, pod length and number of seeds per pod in self pollinations and intravarietal matings.*

Pollination	Percentage of pod setting	Pod length (cm)	No. of seeds per pod.
Toria bagged	12.5	2.5	—
Toria x Toria	96.0	4.8	18
BSA bagged	3.7	3.5	2
BSA x BSA	100.0	4.7	17
LGL bagged	13.0	3.7	1
LGL x LGL	86.2	4.5	19
L-1 bagged	88.0	4.1	13
L-1 X L-1	95.6	4.4	16
RL 16 bagged	83.3	3.6	11
RL 16 X RL 16	92.6	3.8	14
RL 18 bagged	84.0	3.5	12
RL 18 x RL 18	90.0	3.6	13
DGL bagged	18.0	4.0	—
DGL x DGL	86.0	5.5	22

TABLE 2. *Percent pod setting, pod length and number of seeds per pod in intraspecific matings.*

Pollination	Percent of pod setting	pod length (cm)	No. of seeds per pod.
Toria x BSA	88.0	4.5	15
Toria x LGL	95.0	4.6	16
BSA x Toria	91.1	4.4	14
BSA x LGL	96.3	4.5	17
LGL x Toria	92.5	4.2	14
LGL x BSA	94.1	4.4	15
RL 16 x RL 18	88.0	3.3	11
RL 18 x RL 16	84.0	3.1	10

TABLE 3: *Percent pod setting, pod length, and number of seeds per pod in interspecific matings.*

Pollination	Percentage pod setting.	Pod length &(cm)	No. of seeds per pod.
Toria x L-1	92.5	4.5	12
Toria x RL 16	46.1	3.8	5
Toria x RL 18	44.0	3.6	4
Toria x DGL	72.5	4.6	1
BSA x L–1	86.4	4.4	10
BSA x RL 16	12.0	3.5	4
BSA x RL 18	15.1	3.2	3
BSA x DGL	68.0	3.4	4
LGL x L–I	88.0	4.9	15
LGL x RL 16	43.3	3.2	3
LGL x RL 18	38.0	3.7	6
LGL x DGL	37.5	3.2	1
L–1 x Toria	87.5	3.9	11
L–1 x BSA	90.0	4.7	14
L–1 x LGL	77.5	4.5	15
L-1 x RL 16	25.0	4.1	4
L–1 x RL 18	16.0	4.3	6
L-1 x DGL	40.0	4.1	—
RL 16 x Toria	24.0	3.0	4
RL 16 x BSA	27.5	3.2	3
RL 16 x LGL	54.5	3.0	5
RL 16 x L-1	28.5	2.9	2
RL 16 x DGL	75.0	3.4	7
RL–18 x Toria	42.5	3.2	6
RL 16 x BSA	35.0	3.1	4
RL 18 x LGL	33.3	3.0	5
RL 18 x L-1	37.0	3.2	3
RL 18 x DGL	87.5	3.5	9
DGL x Toria	10.5	4.0	2
DGL x BSA	64.0	4.2	8
DGL x LGL	22.5	4.5	3
DGL x L–1	42.5	4.6	1
DGL x RL 16	83.3	4.5	6
DGL x RL 18	76.0	4.8	8

TABLE 4: *Percent seedling emergence, plant height, and number of seeds per pod following a diallel cross of 7 entries.*

Origin of seed	Percent emergence	Plant height (cm)	Pod length (cm)	No. of seeds per pod
Toria selfed	—	—	—	—
Toria x Toria	100	117.3	4.1	16
Toria x BSA	100	111.6	4.0	15
Toria x LGL	95	134.4	3.8	15
Toria x L1	90	171.0	4.3	14
Toria x RL 16	20	181.5	2.7	—
Toria x RL 18	35	197.1	1.9	—
Toria x DGL	—	—	—	—
BSA selfed	—	—	—	—
BSA x BSA	95	109.8	4.2	18
BSA x Toria	85	115.7	4.1	16
BSA x LGL	90	130.0	4.3	17
BSA x L 1	80	168.1	4.0	14
BSA x RL 16	—	—	—	—
BSA x RL 18	—	—	—	—
BSA x DGL	15	197.4	2.7	1
LGL selfed	—	—	—	—
LGL x LGL	90	140.3	4.0	17
LGL x Toria	100	134.8	3.7	16
LGL x BSA	95	131.4	4.5	16
LGL x L 1	85	173.0	4.1	13
LGL x RL 16	—	—	—	—
LGL x RL 18	—	—	—	—

Origin of seed.	Per cent emergence	Plant height (cm)	Pod length (cm)	No. of seeds per pod
LGL x DGL	20	188.2	3.1	2
L 1 selfed	90	186.1	4.0	14
L 1 x L 1	95	193.9	4.2	15
L 1 x Toria	80	175.4	4.5	15
L 1 x BSA	85	180.3	4.3	14
L 1 x LGL	90	179.3	4.4	14
L 1 x RL 16	10	219.2	2.9	—
L 1 x RL 18	—	—	—	—
L 1 x DGL	—	—	—	—
RL 16 x selfed	95	209.9	3.7	12
RL 16 x RL 16	90	211.5	3.8	13
RL 16 x Toria	15	198.7	2.0	1
RL 16 x BSA	—	—	—	—
RL 16 x LGL	—	—	—	—
RL 16 x L 1	25	225.4	2.1	—
RL 16 x RL 18	95	221.3	3.4	14
RL 16 x DGL	60	243.1	1.5	1
RL 18 x selfed	90	211.3	3.6	13
RL 18 x RL 18	100	214.1	3.6	14
RL 18 x Toria	20	207.8	2.2	1
RL 18 x BSA	—	—	—	—
RL 18 x LGL	—	—	—	—
RL 18 x L 1	—	—	—	—
RL 18 x RL 16	90	230.2	3.5	14

Origin of seed.	Per cent emergence	Plant height (cm)	Pod length (cm)	No. of seeds per pod
RL 18 x DGL	75	247.7	2.2	3
DGL selfed	—	—	—	—
DGL x DGL	95	219.8	5.5	21
DGL x Toria	—	—	—	—
DGL x BSA	35	217.2	2.8	2
DGL x DGL	30	223.5	3.3	3
DGL x L 1	—	—	—	—
DGL x RL 16	70	259.1	1.7	2
DGL x 18	80	265.7	2.1	3

TABLE 5: *Percent pod setting and average number of seeds per pod after indicated intervals between pollination and excision.*

Pollinations.	2 hours		4 hours		6 hours		8 hours		10 hours		12 hours	
	% pod setting	seeds per pod.	% pod setting	seeds per pod.	% pod setting	seeds per pod	% pod setting	seeds per pod.	% pod setting	seeds per pod	% pod setting	seeds par pod.
Toria selfed	—	—	—	—	—	—	—	—	—	—	—	—
Toria x Toria	—	—	—	—	80	15	90	17	100	18	100	18
BSA selfed	—	—	—	—	—	—	—	—	—	—	—	—
BSA x BSA	—	—	—	—	90	14	100	16	100	17	100	16
LGL selfed	—	—	—	—	—	—	—	—	—	—	—	—
LGL x LGL	—	—	—	—	80	14	90	16	90	17	100	18
L 1 selfed	—	—	—	—	70	10	80	12	80	13	80	13
L 1 x L 1	—	—	—	—	80	12	80	13	90	14	90	14
Toria x BSA	—	—	—	—	80	11	90	13	90	12	90	14
BSA x LGL	—	—	—	—	90	13	90	14	100	16	100	17
Toria x L 1	—	—	—	—	70	10	80	12	80	12	90	13
L 1 x BSA	—	—	—	—	80	10	90	13	90	14	90	14
L 1 x RL 16	—	—	—	—	—	—	—	—	20	3	30	3
Toria x RL 18	—	—	—	—	—	—	—	—	40	2	40	4
LGL x DGL	—	—	—	—	—	—	—	—	—	—	30	1
DGL x L 1	—	—	—	—	—	—	—	—	30	—	40	1
RL 18 x DGL	—	—	—	—	—	—	80	7	90	8	90	8
RL 16 x RL 18	—	—	—	—	80	9	90	10	90	9	90	11
RL 18 x LGL	—	—	—	—	—	—	—	—	30	3	40	4
RL 16 x BSA	—	—	—	—	—	—	—	—	20	—	30	1

inter-speific crosses a relatively poor seedset was obtained, which may be attributed either to a slower pollen-tube growth or to genetic incompatibility of the gametes or to both.

It appears that the extent of success expected from selfing and crossing depends upon the speed of the pollen-tube traversion inside the stylar tissue and/or the compatibility of the participating male and female gametes, the latter, in turn, would evidently depend upon phylogenetic relationship of the parents involved.

From the results of the present study, it may be concluded that though interspecific crosses can be made among different Brassica species with a varying degree of success, three species, *Brassica compestris, B. trilocularis* and *Brassica napus* show a closer relationship amongst themselves which fact a breeder may keep in view in his efforts to improve his stocks.

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