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Artificial *Brassica napus* flowering in Bangladesh

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Summary. Natural rapeseed (*Brassica napus* L.; AACC 2n=38), originated in the temperate climate of the Southwest European Mediterranean region, fails to complete its generative phase in the subtropics and is thus not cultivated in countries like Bangladesh. Adapted agroecotypes are available from the diploid representatives of its genome A (*B. campestris/pekinensis*, 2n=20) and C (*B. oleracea/alboglabra*, 2n=18). An artificial resynthesis based on carefully selected progenitor lines was expected to give a photoperiodically better adapted rapeseed. ♀ *B. pekinensis* × ♂ *B. oleracea/alboglabra* gave 2 hybrids and 87 matromorphous plants from 1,448 crossed flowers and the reciprocal combination gave no hybrid but 11 matromorphous plants from 2,228 pollinated flowers. The two true hybrids were vegetatively propagated and chromosome doubled. Part of the F_2 was grown in Sweden (all plants flowered and the most early ones were selected), part in Bangladesh (13 out of 706 plants flowered). The selected F_3 material flowered in Bangladesh and transgressions in earliness could be recorded, some lines were of definite agronomic potential. A correlation in earliness between reaction in Sweden (long day) and Bangladesh (short day) was observed.

Key words: *Brassica napus* – Resynthesis – Adaptation to short day – Earliness

Introduction

Brassica napus or rapeseed (2n=38,AACC) is an amphidiploid between *Brassica campestris* (2n=20,AA) and *Brassica oleracea* (2n=18,CC). In nature, this species synthesis is believed to have originated in the Southwest European Mediterranean region (Sinskaya 1928; Schiemann 1932; Olsson 1960; Zeven and Zhukovsky 1975). It evolved from diploid genotypes adapted to a temperate climate and its daylength regime. Generatively more productive than its diploid parent *B. campestris*, *B. napus* has become the leading oil crop in Northwestern Europe and Canada. An advanced breeding programme has produced high-yielding and high-quality cultivars adapted for the concerned climate where the growing season is limited to the summer with its long days. For the purpose of oil production, *Brassica* species are also important crops on the Indian subcontinent. Here they are, however, winter crops in a dry and hot subtropical climate with approximately 12 hours of day length.

In this short-day environment only *B. campestris* and *B. juncea* (2n=36,AABB) are able to flower and set mature seeds in due time. *B. napus* reacts by an inability to switch over to the generative phase (Table 1) and has for that reason not been used in Bangladesh, Pakistan or India (cf. Prakash 1980). Only some very early representatives have been able to flower here but too late for producing a compatitive seed yield. The more proliferous northern cultivars stay constantly green. Similar observations have been reported for other crop plants introduced from the north into the tropics. Vergara (1975) mentions such crops from the temperate zone as *Raphanus sativa*, *Lactuca sativa* and *Spinacea oleracea*. Northerly representatives of *B. campestris* and *B. oleracea* do not flower in the subtropics, but these two species are, in contrast to *B. napus*, represented by appropriate agroecotypes. This situation called for a resynthesis of *B. napus*, from genome A and C representatives carrying the right

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response to 12 h daylength. Such an approach ought to produce a *B. napus* adapted to Bangladesh. This country as well as neighbouring ones are short of vegetable oil but also of arable land. A more productive representative of *Brassica* should thus be highly wanted.

Materials and methods

As an initial step, a search was made for the most appropriate representatives of the two parental species *B. campestris* L. and *B. oleracea* L. Material of different origins was brought together and evaluated both under the short-day regime wintertime at the Bangladesh Agricultural Research Institute in Joydebpur, Bangladesh (24°0′N lat.) and under long-day regime summertime at the Weibullsholm Plant Breeding Institute in Landskrona, Sweden (55°55′N lat.). In the preliminary studies reported herein, one genome A representative belonging to *B. campestris* ssp. *pekinensis* (2n = 20,AA) was chosen. It originates from Taiwan and was kindly supplied by the Asian Vegetable Research and Development Centre, in Shanhua, Taiwan. It was classified as entry B23. The genome C was represented by one broccoli type of *B. oleracea* cv. 'Early Corona' from F. Sutton Seed Ltd, England and one type of *B. oleracea* var. *'alboglabra'* (2n = 18,CC) obtained from the Plant Breeding Institute, Cambridge, U.K. and of Southwest Asian origin.

The crosses *B. campestris* B23 × *B. oleracea* cv. 'Early Corona' and *B. campestris* B23 × *B. oleracea* var. 'alboglabra' were made reciprocally. Floral buds were emasculated one to two days prior to opening and properly bagged after immediate pollination. Potential hybrid seeds were sown in peat soil and seedlings were screened morphologically as hybrids or matromorphous plants. Seedlings with hybrid characteristics were conclusively controlled by chromosome counts from root tip smeares. The primary hybrid plants were chromosome doubled by colchicine treatment after vegetative propagation. Each clone was partly selfed after colchicine treatment and partly crossed with the Swedish *B. napus* cv. 'Olga'. All these primary steps were taken with greenhouse and laboratory facilities in Sweden. Selection in following generations was facilitated by the opportunity to grow one crop during the winter in Bangladesh and another crop during the summer in Sweden each year.

Results and discussion

As frequently observed (see Namai et al. 1980), there exists a considerable crossing barrier between the genome AA and genome CC species of *Brassica.* The present results confirm that the barrier is more effective when genome CC is used as the female (Table 2).

There are different explanations for the comparatively high frequency of matromorphous plants obtained. Apart from the possibility of incomplete emasculation and selfing, a parthenogenetic development of the haploid egg cell may occur as an effect of pseudogametic stimulation (Olsson and Hagberg 1955). It appears to be important that pollen tubes penetrate towards the ovule in order to have this process come about (Röbbelen 1965). A doubling of the haploid chromosome set appears to be promoted by pseudogamy, which will explain the comparatively frequent occurrence of matromorphous plants observed in interspecific *Brassica* crosses (Naguchi 1928; U 1935; Mohammad and Sikka 1940; Ramanujam 1940; Olsson 1960).

Table 1. A collection of *B. napus* (spring types) grown in Bangladesh and in Sweden

Germplasm no./cv. name	Country of origin	No. of days to flowering	
		Bangladesh 24° 0′N	Sweden 55° 55′N
'VIR 4360'	Japan	–	45
'VIR 4388'	Japan	–	60
'VIR 4309'	Morocco	–	47
'VIR 4307'	Morocco	–	48
'BRA 99/78'	Czechoslovakia	–	47
'BRA 1/78'	France	–	42
'BRA 5/78'	E. Germany	–	43
cv. 'Gulliver'	Sweden	–	41
cv. 'Olga'	Sweden	–	46
cv. 'Hanna'	Sweden	–	49

–: means do not flower in Bangladesh

Table 2. Results from interspecific crosses between *B. campestris* ssp. *pekinensis* (AA) and *B. oleracea/alboglabra* (CC)

	♀AA×♂CC	♀CC×♂AA
No. of buds pollinated	1,448	2,228
No. of seeds obtained	87	11
Thereof inviable	7	5
Matromorphous	78	6
True hybrids	2	0
% hybrids	0.13	0.00

Two hybrid seeds were obtained, one each from the two above-mentioned combinations. Plants from these seeds were characterized by large round leaves and flowers similar to those of the genome AA parent, were highly sterile and showed more of a perennial growth habit. They were thus easily vegetatively propagated. The amphidiploidization through colchicine treatment gave 3 plants from the *pekinensis* × *oleracea* combination and 2 plants from the *pekinensis* × *alboglabra* combination. The cross to natural *B. napus* gave 5 and 13 plants, respectively. The characteristics of all 23 plants are compared with their parents and the *B. napus* cv. 'Olga' when grown in the Swedish long-day climate (Table 3). The synthesized *B. napus* resembled the natural *B. napus* in key morphological/taxonomical characters. None of the synthesized or half-artificial rapeseed plants (altogether referred to as F_1) was, however, characterized by the desired earliness of their *pekinensis* progenitors.

The F_1 plants were allowed to intercross and part of the F_2 generation was field sown the following winter

Fig. 1. Artificial rape flowering normally (*at left*) while the Swedish cultivar 'Olga' remains in its vegetative state (*at right*) when grown during the winter (1983–84) in Joydebpur, Bangladesh

Table 3. Characteristics of artificial and semi-artificial *B. napus* in F_1 along with their progenitors when grown under long day climate in Sweden (Mean and ± SE)

	Natural	Artificial and semi-artificial *B. napus*						
	B. napus cv. 'Olga'	*pekinensis* × *oleracea* 4x	*pekinensis* × *alboglabra* 4x	(*pekinensis* × *oleracea*) × *napus*	(*pekinensis* × *alboglabra*) × *napus*	*B. pekinensis*	*B. oleracea* cv. 'E. corona'	*B. alboglabra*
Plant height cm	110.1 ± 1.23	141.0 ± 1.15	205.5 ± 0.49	135.6 ± 3.32	174.9 ± 3.98	64.6 ± 0.80	85.4 ± 1.23	110.2 ± 0.91
Leaf lamina length cm	15.7 ± 0.12	22.9 ± 0.54	24.7 ± 0.24	23.4 ± 0.67	19.7 ± 0.72	12.4 ± 0.55	11.5 ± 0.10	13.8 ± 0.33
Leaf lamina width cm	11.2 ± 0.07	18.2 ± 0.68	22.5 ± 0.0	15.3 ± 0.58	17.2 ± 0.64	9.8 ± 0.40	6.5 ± 0.10	9.5 ± 0.22
No. of primary branches	5.2 ± 0.32	7.0 ± 0.57	5.5 ± 0.49	6.0 ± 0.44	7.8 ± 0.51	3.4 ± 0.16	4.9 ± 0.31	3.4 ± 0.16
No. of secondary branches	4.4 ± 0.45	16.3 ± 0.88	17.5 ± 0.50	11.8 ± 0.97	16.6 ± 1.02	4.5 ± 0.37	4.3 ± 0.51	3.7 ± 0.42
No. of days to flowering	54.7 ± 0.21	51.7 ± 0.66	45.0 ± 2.99	51.6 ± 0.39	45.5 ± 0.34	42.1 ± 0.37	83.2 ± 0.46	59.0 ± 0.39
No. of days to maturity	110.4 ± 0.68	135.0 ± 1.15	114.0 ± 0.0	129.0 ± 1.93	116.5 ± 0.18	96.4 ± 0.33	147.3 ± 0.30	136.4 ± 0.47
Pollen fertility %	98.2 ± 0.18	69.5 ± 3.05	65.5 ± 0.99	72.5 ± 4.76	81.4 ± 1.17	95.7 ± 0.38	96.3 ± 0.36	90.2 ± 1.26
No. of plants studied	10	3	2	5	13	10	10	10

in Bangladesh. All together 706 F_2 plants were obtained, of which only 13 were able to flower. The rest remained in vegetative state as did the Swedish rapeseed cultivar 'Olga'. Another part of the F_2 generation was sown in Sweden, where all plants were able to flower and produce mature seeds in the long-day summer. Out of 2,614 F_2 plants, 239 were selected for earliness. The number of days to flowering among the selected plants ranged from 39 to 51 days. In comparison, the two Swedish cultivars 'Olga' and 'Hanna' flowered 56 and 59 days after sowing, respectively. Seeds from the selected plants were sown as F_3 in Bangladesh the following winter. While the Swedish representatives of *B. napus* again failed to flower, some of the reselected lines were able to flower, in some cases even exhibiting a transgressive earliness compared to F_2. The F_3 generation showed a considerable variation as to fertility, plant height and other agronomically important characters.

The most promising lines are now subjected to further recombination and selection in a breeding programme at Bangladesh Agricultural Research Institute with an ambition to try to introduce rapeseed as a more productive *Brassica* oil crop for the country. It might also be of interest to observe that rapeseed genotypes adapted for Bangladesh behave also as early maturing types in Sweden and may there have potentials for moving cultivation of summer rape even further north.

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