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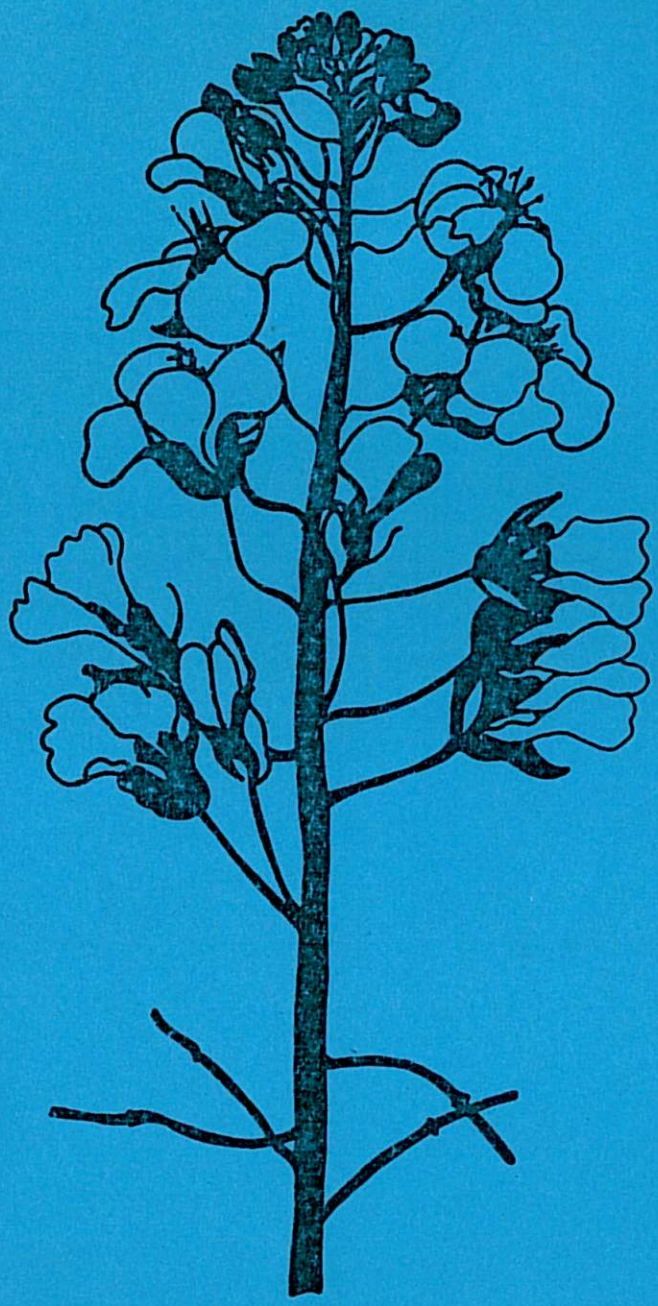

November 1982

EUCARPIA

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COLLECTING IN ETHIOPIA

D. Astley

The Plant Genetic Resources Center (PGRC), Addis Ababa continued the collection of Ethiopian germplasm during January-February 1982, with the support of the International Board for Plant Genetic Resources, in the west and south-western areas of the country. Previous collecting expeditions had identified Brassica crops as warranting special interest.

The PGRC in collaboration with the Institute for Agricultural Research (IAR) in Ethiopia have made collections of oil seed forms of Brassica carinata in the provinces of Bale, Begemdir Simen, Gamo Gofa, Gojam, Hararge, Shoa, Sidamo, Wollega and Wollo. The crop is commercially important for seed oil production with the oil content of the dry seed ranging from 29 to 38%. The search for accessions with low erucic acid and low glucosinolate levels has been initiated by the IAR Station at Holeta.

The utilisation of B. carinata as a leaf vegetable had been noted (Simmons, 1976; Westphal, 1975), but, the extent of this usage and that of other brassicas was not altogether clear.

The expedition collected in the Ethiopian Highlands and in the valleys of the Omo and Baro rivers in the provinces of Kefa, Illubabor, Sidamo, Shoa and Wollega. Large tracts of climax forest were evident on the rolling highlands of the three western provinces, although in certain regions agriculture and road construction were encroaching on these forest areas. Coffee collected from wild and cultivated plants was the major crop in the forest zones below 2000m.

The higher deforested areas were densely agricultural, the only trees being planted were Eucalyptus for building and firewood. A wide range of starch crops was grown depending on the altitude, eg. tef, barley, wheat, sorghum, maize, finger millet and ensete. Pulses and other vegetables were common as backgarden crops.

Agriculture in the hot, dry lowlands of Illubabor province was restricted to the floodplains of the major rivers. Sorghum and maize were the staple starches with okra and various fruits being grown as cash crops in the Baro river valley.

Brassica crops were seen throughout the altitudinal range, 500m to 2900m. Various crop types distinguished on morphology, use, linguistic evidence and cultural practice were collected. The material was identified as follows:

1. Brassica nigra - Leaves and seeds were used medicinally for rheumatism and stomach ailments. Plants were grown intercropped with finger millet or in kitchen gardens mixed with B. carinata, the seed being harvested separately. The Amharic name for the crop was Senafitch.
2. Brassica carinata - Of the 56 rapes collected only one was utilised exclusively for seed oil. This was a commercial crop grown on a large scale. The remainder (55) were multipurpose crops used for seed oil (commercial), seed oil for polishing, leaf production and for the sale of seed. Various local names were used for the crop: Gomen and Gomenzerr (Amharic); Rafu and Ija Raffu (Oromo); Shano and Chachafo (Kefa); Fortera Gomen (Gorage); Dankali (Hadea); Dankala (Wellita).
3. Brassica sp. - A seed propagated leaf vegetable was sown in a seedbed and transplanted into a manured plot. The leaf production was very good and formed a major dietary constituent in certain areas. Local names for the crop were: Abrango (Oromo); Koyo or Shoko (Kefa); Gunamber or Goaro Gomen (Gurage); Hamelo or Chacafo (Kembatenya). (Possibly B. carinata or B. oleracea).
4. Brassica sp. - A leaf vegetable propagated by side shoot cuttings. The local farmers had never seen seed of this group. Local names included: Abrango (Oromo); Koyo or Shoko (Kefa); Sumeria or Simarita (Kembata). (Possibly B. oleracea).

The wide range of variation collected by the mission will be of value in defining the specific limits of the taxa involved. The clarification of these taxonomic relationships will be valuable to PGRC in the characterisation of present collections and for future collection missions.

The collections will be multiplied, characterised and stored at the PGRC, Addis Ababa, Ethiopia.

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REPORT FROM AN OILCROP COLLECTION TRIP IN ETHIOPIA

K.W. Riley and Hiruy Belayneh

This trip was made between November 24 and December 19, 1981. Collections were made primarily from standing crops in farmers' fields in parts of Wellega Region, west of Addis Ababa, and in Gojjam and Gondar Regions, northwest of Addis Ababa.

Ninety collections were tentatively identified as Brassica carinata and six as B. nigra. Both species were found in highland areas, but a few collections of B. carinata were made in mid-altitude areas (Table 1).

Table 1. Elevation means and ranges (metres above mean sea level) of Brassica collections.

Species	Mean	Range
B. nigra	2320	2000 - 2510
B. carinata	2225	1700 - 2610

Both Brassica species were generally intercropped in small fields or gardens close to houses, with one or more of the following crops : maize, finger millet, squash, coffee, grain amaranth, or Coleus (tubers used as potato). Neither Brassica species was found where soil fertility or drainage was poor. Planting date most commonly reported was early June, but ranged from April to August.

In all areas, B. carinata was known by only a single name - gomenzer, and B. nigra was known as senafitch. Land races with specific names did not appear to exist. However there was considerable variation from plant to plant within fields and from field to field. Plant height ranged from 60 to 200 cm; estimated growth period from 4 to 8 months, and branching from profuse to sparse. Most seeds of B. carinata were light brown in color, but one pure yellow seeded collection was made. Seeds of B. nigra were all greyish-black.

Aphids were reported by farmers to be the most serious pest of the crop. B. nigra appeared to suffer more than B. carinata. Some plants of B. carinata were free of aphids, and others were yielding well in spite of heavy attack.

Alternaria leaf spot was the most common disease, seen on the leaves but was not seen on the pods. A trace

of white rust/downey mildew was occasionally observed.

Forty three farmers gave replies to questions about the way they used B. carinata. Sixty six percent of farmers used part of the crop in the home, and marketed the rest. The other 34% used the entire crop in the home. The importance of the different uses of the crop in the home are shown in Table 2.

Table 2. Home uses of B. carinata.

Uses	Percentage of positive replies
Oil extraced with hot water*	37
Bread pan greased with crushed seed	74
Parched seed crushed, made into soup	12
Leaves boiled and eaten	85
Crushed seed used to soften leather	7
Crushed seed used in spice	30

*Oil is extracted by parching and crushing the seed into a fine powder. Boiling water is added while stirring the mixture. The mixture is shaken, until the oil rises. The oil is then decanted.

Some additional comments on crop use were made by farmers :

- The cake or meal remaining after oil extraction may be mixed with barley and given to a woman after she has delivered a baby.
- The taste of cake or meal improves after standing overnight.
- The ground seed is used to treat an upset stomach.
- The branches are used as a broom.

B. nigra was used in much the same way as was B. carinata. It was often used to grease the bread pan; as a component of a spicy sauce known as awazi; and to soften leather. In addition, the parched seed was made into a soft stew called wat, during the fasting time.

This collection trip was made in collaboration with the Plant Genetic Resource Centre for Ethiopia.

THE ORIGIN AND DIFFERENTIATION OF MUSTARD VARIETIES IN CHINA

Shi-ru Chen

Vegetables are an important component of the daily diet of the Chinese. China has a great diversity of cultivated vegetables and there are many methods of processing vegetables. There are many special forms of vegetables locally adapted to limited regions of China. In the Cruciferae, within Brassica, there is a long history of cultivation and a wide diversity of morphotypes and cultivars is found throughout the country. Owing largely to different ecological adaptations, Chinese cabbage (Brassica campestris var. pekinensis) predominates in the North, whereas mustard (Brassica juncea) prevails in the South.

Mustard is characterized by the distinctive, pungent flavor from volatile mustard oil found in both the seed and vegetative organs. Mustard is higher in carotene, thiamine, riboflavin, and ascorbic acid than cabbage (B. oleracea var. capitata) and Chinese cabbage. A processed product of stem mustard, "Zacai", is crisp and tender. Hydrolysis of protein into amino acids during processing results in a highly desirable flavor which accounts for its great popularity among the Chinese, Japanese, and Southeast Asians.

Mustard is cultivated in both fields and vegetable gardens. For example, in the Hulin district of Sichuan province, a rotation system is widely practiced in which mustard follows sweet potato or proceeds maize. Mustard is frequently inter-cropped with broad bean (Vicia faba L.) or wheat (Triticum astivum) in most parts of Sichuan. In Zhejing province mustard is often planted between mulberry trees, whereas in Hunan and Quantong provinces mustard is grown after lowland rice and taro are harvested.

Over centuries of cultivation, Chinese farmers have selected numerous morphotypes and cultivars of mustard for their root, stem, shoots, or leaves from the segregants of natural crossing and spontaneous variants. The greatest diversity of mustard morphotypes and cultivars is found in Sichuan, including stem mustard, an important processing vegetable.

Origin and history of cultivation of mustard

1. Records of mustard cultivation in Chinese classical literature.

China has a very long history of mustard cultivation. As early as in the West Han Dynasty (206 B.C. - 24 A.D.), Dai in his work, Liji (The Book of Rites), described "a jam of fish slices with mustard" which suggests that mustard was already in use as a flavoring agent. Possibly it was cultivated long before that time. In the North Wei Dynasty (386 - 534 A.D.), Jia in his famous work, Qi Ming Yao Shu (People's Essential Techniques), wrote, "As for Sichuan mustard and other Brassica, if grown for their leaves, sow in mid-July; if their seed is wanted, sow in February or March when there is plenty of rain." What he referred to here as "Sichuan mustard" grown in the northern part of China, may well have been a cultivar introduced from

Sichuan. In the North Song Dynasty, Su (1061) recorded in Tu Jin Ben Cao (Illustrated Book of Medicinal Herbs) that "Mustards may be found everywhere". The green mustard variety is similar to Chinese cabbage in appearance, but is covered with tiny hairs and is very pungent. The purple mustard, with stem and leaves all purple in color, is ideal for flavoring." Such a description indicates that the culture of mustard had become quite wide spread at that time and there were at least green and pruple varieties. Wang (1576 - 1588) in his work, Gua Guo Shu (Explanations of Cucurbit and Vegetable Crops), recorded some root mustard types. And Li (1578) of the Ming Dynasty in his famous work, Ben Cao Gang Mu (Compendium of Materis Medica), described many leaf and shoot mustard varieties. From the above literatures it is clear that mustard was cultivated in China several centuries B.C. At that time there were few types and cultivars were used primarily for powdered condiments. During the Ming Dynasty, leaf, shoot, and root mustard types appeared. Stem mustard probably arose later, in the Qing Dynasty. No records of stem mustard and its processed product, "Zacai", have been found in the literatures before the Qing Dynasty.

2. The origin of mustard.

Almost 50 years ago, the Japanese scholars, Morinaga (1934) and U (1935), discussed the relationship among the various species of Brassica. Morinaga was the first to suggest that mustard (B. juncea) owes its amphidiploid origin (2n = 36, aabb) to the hybridization between black mustard (B. nigra, 2n = 16, bb)and rape (B. campestris, 2n = 20, aa). Morinaga's hypothesis was substantiated by the artificial synthesis of mustard by Fransdon (1943) in Europe and Ramanujam and Shrinivasachar (1943) in India. Hybrid B. juncea may be synthesized by utilizing either B. campestris or B. nigra as a maternal parent. Synthesized mustard is very similar to the natural mustard. Prakash (1973) thoroughly investigated the artificial synthesis of mustard.

What about the natural origins of mustard? Prain (1898), Sinskaia (1928), and Vavilov (1949) believed that mustard originated in Asia, with its major diversification in China. Vavilov assigned Afghanistan and adjoining regions as the primary center of origin and suggested that central and western China, eastern India, and Asia Minor through Iran formed the secondary centers of evolution. Sun (1970) states that mustard evolved in the Middle East in prehistoric times. Olsson (1960) believed that B. juncea originated in several different regions such as the Middle East and neighboring regions where B. nigra and B. campestris overlap in their distribution. Olsson's notion of polyphyletic origin has been supported by the work of Vanghan, Hemingway, and Schofeld (1963).

Considering that mustard, as an oil crop, is widely distributed throughout China, India, Egypt, south and southwest Russia, and Europe, it is interesting that, as a vegetable crop, it has been primarily restricted to China. Based on the number of mustard varieties found there, it is clear that China is the center of diversity and origin of cultivated vegetable forms.

Differentiation of various morphotypes and varieties of Chinese mustard

In China, oil mustard is grown chiefly in Yunnan province and to a lesser degree in Gansu, Qinghai, and Xinjiang. Though several hundred oil seed mustard cultivars exist, its variation is far less than that of vegetable mustard.

Primitive types of cultivated vegetable mustard are small in size with poor leaf growth. These forms were grown for the pungent mustard seed powder. During the course of cultivation, variants in leaf size, color and thickness, in the degree of leaf lobing, in petiole width, and in the heading or spreading of the leaves were selected. Generally, few or no branches develop from the axillary buds before bolting. However, there are types which branch early in the vegetative stage giving rise to the potherb mustard (B. juncea var. multiceps). Improvement in cultivation practices permitted the expression of stem and root swelling characters and led to the development of various cultivars of root and stem mustards. Recently, a variant has been found which resembles brussels sprouts (B. oleracea var. gemmifera) with the development of many swollen axillary buds prior to elongation of the flowering axis. The variants observed in cultivated mustard are virtually parallel to those variants found in the cole crops and morphotypes of B. campestris.

The main morphotypes of vegetable mustard in China

1. Mustards grown for their leaves: Annual or biennial with well-developed leaves which can be eaten fresh or processed. The main varieties are as follows:
   a) Broad-leaf mustard (B. juncea var. rugosa): Plants are large with broad and large green or purple leaves, leaf margins are entire, waved or dentaled, and few with slight lobing. This type of mustard is grown throughout China. Cultivars are more numerous in the South than in North China.
   b) Dissected-leaf mustard (B. juncea var. multisecta): Plants have varying degrees of leaf dissection.
   c) Strumiferous leaf mustard (B. juncea var. strumata): Plants have large leaves and well-developed petioles. Tumor-like protuberances emerge from the petiole where it joins the stalk. Cultivars are mainly grown in Zhejiang, Hubei, and Sichuan provinces.
   d) Head leaf mustard (B. juncea var. capitata): Plants have large leaves with broad petioles and midribs. The youngest leaves fold inward, overlapping each other to form a ball-shaped head. Such cultivars are mainly grown in South China.
   e) Tillering mustard (B. juncea var. multiceps): Plants have many vigorous lateral buds on a shortened stem. "Tillers" develop before flowering. The degree of tillering varies with cultivars. Cultivars are generally referred to as potherb mustards. They are generally cold-resistant, and are cultivated both in the northern and southern parts of China.
2. Mustards grown for their stem (B. juncea var. tsatsai): Plants are biennial with swollen stems which may be rod-shaped or variously enlarged with tumor-like protuberances just below the petiole where it joins the stem. Leaves are generally large and either green or purple, the leaf surface may be smooth or rugose, and leaf blades are entire or dissected. These are grown for their stems which are either processed or eaten fresh. Leaf texture is coarse as compared with leaf mustard and is not generally eaten. Stem mustard cultivars evolved in Sichuan and have been introduced into Zhejiang, where they are now widely grown.
3. Mustards grown for their shoots (B. juncea var. scaposus): Plants are

annual or biennial with an erect habit. Leaves are either oblong or oval with entire or lightly dissected blades. Their swollen shoots are used for processing or eaten fresh. Such cultivars are grown in Sichuan, Zhejiang, Guangdong, Yunnan, and Guizhou provinces.

4. Mustards grown for their roots (B. juncea var. napiformis): Plants nave fleshy cylindrical or conical taproots used for processing. Leaves are either green of purple with entire or dissected blades. Cultivars are grown throughout China.

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MORPHOLOGICAL CHARACTERS OF F_4 PROGENY OF THE HYBRID BRASSICA CAMPESTRIS SSP. PEKINENSIS CHINESE CABBAGE X B. CAMPESTRIS SSP. TRILOCULARIS YELLOW SARSON WITH DIFFERENT SEED COAT COLOUR

Barbara Barcikowska

During the year 1982 we have been trying to get some information dealing with relations between yellow seed coat and plant vigour. To reach this aim we have been sown F_4 generation of the hybrid Brassica campestris ssp. pekinensis Chinese cabbage X B. campestris ssp. trilocularis Yellow Sarson during this spring in the greenhouse. The results illustrating the measurements, at the beginning of flowering period, of some morphological characters of plants investigated are listed in Table 1.

Table 1. Morphological characters of F_4 progeny of the hybrid B. campestris ssp. pekinensis Chinese cabbage X B. campestris ssp. trilocularis Yellow Sarson with different seed coat colour.

No	Number of plant	Seed coat colour	Number of plants invest.	Height of plants (cm)		Number of shoots	The greatest leaf		Number of leaves
				1	2		length	width	
1	405N/1	dark brown	71	104,9	137,6	3,3	21,4	10,1	11,6
2	405N/4	" "	76	88,3	112,6	5,7	21,4	9,7	9,8
3	405N/12	pale yellow	44	89,2	109,7	3,3	17,1	8,1	9,4
4	" "	dark yellow	56	81,4	101,4	3,4	16,5	8,1	8,8
5	405N/22	dark blue	76	110,8	115,7	3,9	15,9	8,3	7,8
6	405N/28	pale yellow	74	89,7	109,6	3,3	15,7	7,7	10,8
7	" "	dark yellow	74	89,1	118,4	4,7	16,9	9,2	9,4

1 - at the beginning of flowering period

2 - during full maturity

As it can be seen, there is only a slight tendency by plants originating from yellow seeds, to diminished height at the time of full maturity. But at the beginning of flowering period the plants with yellow seed coat, although this is a recessive character, seem not to be less vigorous than the others. This is promising for the future because it suggests, that selection for yellow seed coat during following generations may lead to reach vigorous and yellow seeded B. campestris plants, as valuable parental forms for artificial B. napus breeding.

INFLUENCE OF THE CYTOPLASM OF INDIAN SELF-INCOMPATIBLE LINES ON THE EARLINESS AND QUALITY OF F_1 CAULIFLOWER CURDS

J. Hoser-Krauze, J. Gabryl and J. Antosik

Materials and Methods

The parental components of F_1 hybrids were: homozygous self-incompatible lines of three Indian cultivars varying in their maturity period and self-compatible lines of three temperate climate cultivars of summer cauliflower (Table 1). The Indian cultivar Pusa Katki possesses a dominant gene that governs weak growth and the premature formation of nonmarketable curds under the Polish agricultural and climatic conditions in the field (J. Hoser-Krauze, J. Gabryl, 1978) . For that reason the parental lines and F_1 hybrids of this cultivar were grown in 1981 in a greenhouse at a temperature of 18-25 °C. The other parental lines and their F_1 hybrids were compared under field conditions suitable for early summer cultivars during the 1980 growing season. Sowing and planting dates, and plant spacings are shown in table 1. Observations covered: the number of leaves, date of curd maturity, their diameter, weight and quality. Curds were harvested every third day. The curd diameter was measured along the arc. The quality of curds was divided into five classes: the 1st and 2nd class complied with the Polish commercial standard, while 3, 4 and specified 5 non-marketable curds; the 5th class comprised broccoli-like curds. The data defining the characters under observation were grouped into frequency distributions on the basis of which the arithmetic means $\bar{x}$ and standard deviation were calculated. Results were interpreted statistically with the application of the formula of Hovanitz , 1953 .

Results

The earliness of curd maturity of the F_1 hybrids investigated was determined by additive polygenes. This was consistent with the results presented by several authors eg Watts (1964) , Kumaran (1972) , Singh, Swarup & Chatterjee (1975), Crisp (1977) and Hoser-Krauze & Gabryl (1978). Moreover the influence of the cytoplasm of maternal lines on this character was observed: F_1 hybrids H x K and 20 x 14 having as the mother component somewhat later lines H and 20 with a greater number of leaves than the father lines K and 14 were earlier than their reciprocal hybrids K x H and 14 x 20 (Table 1) . F_1 hybrids H x K and 20 x 14 showed heterosis statistically significant in the earliness of curd maturity. This increased earliness of curd maturity by the cytoplasm caused significant reduction in the diameter and weight of curds, worsening their quality. The influence of cytoplasm still occurred in the threeway cross (20 x 14) x 401, as compared to the reciprocal (14 x 20) x 401, which was two days later and showed heterosis in the diameter, weight and quality of curds. In these hybrids the father line no. 401 of the summer cv. Rapid was very similar in earliness to the mother Indian lines nos. 20 and 14. In the case when the father line no. 381 was later than the Indian mother lines H and K, and the father line no. 644 later than lines no. 20 and no. 14, then the differences between their reciprocal three-way crosses (H x K) x 381, (K x H) x 381 and (20 x 14) x 644, (14 x 20) x 644 were not significant.

Conclusions

1. In the breeding of very early F_1 cauliflower hybrids the influence of cytoplasm on the earliness and quality of curds can not be ingnored.

2. Heterosis in curd diameter, weight and quality can occur in the early F_1 hybrids between self-incompatible lines of the Indian cultivars and self-compatible lines of summer cultivars with similar maturity periods to each other cultivated in the temperate climate.

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Table 1a

Mean values of some cauliflower characters of parents and F_1 hybrids

Parents, hybrids F_1 and orgigin of cv.		Cv. code no.	Number of leaves			Days to maturity		
			Total No of plants N	Mean $\bar{x}$	Standard deviation S	N	$\bar{x}$	S
H-Pusa Katki	India	1	32	15,1^{xx}	2,81	32	68,8	7,13
K-Pusa Katki	India	2	31	13,1	1,67	31	67,7	7,55
14-PI 271445	India	3	72	12,0	3,24	73	116,8	9,19
20-PI 277277 Late Banaras	India	4	40	14,5^{xx}	3,84	40	118,2	9,54
381-Early Abundance Stokes Seed	Canada	5	47	18,9	1,67	47	99,7	6,26
401-Rapid	Poland	6	58	18,9	1,98	134	118,5	10,28
644-Idol Ohlsens Enke	Denmark	7	41	20,7	2,02	132	125,5	7,00
F_1 H x K		8	35	12,6	2,20	35	63,1^{xx}	9,06
F_1 K x H		9	30	12,9	2,26	30	69,6 ^{x}	7,72
F_1 H x K x 381		10	30	16,3	2,00	30	76,4	5,08
F_1 K x H x 381		11	29	15,2	2,14	29	75,2	2,04
F_1 20 x 14		12	86	12,7	3,66	87	111,5^{xx}	8,69
F_1 14 x 20		13	103	15,0^{xx}	4,67	109	116,6	9,81
F_1 20 x 14 x 401		14	56	17,5	1,81	129	119,3	11,75
F_1 14 x 20 x 401		15	54	17,4	1,96	140	121,2	10,43
F_1 20 x 14 x 644		16	59	19,9	1,86	131	122,7	9,46
F_1 14 x 20 x 644		17	50	20,0	2,00	142	120,2	10,49

xx Significant difference at confidence level P = 0,01
x Significant difference at confidence level P = 0,05
[Parentheses designate values compared
xx x Significant difference between the reciprocal hybrids and better parent value
1/ 1st class designates the best commercial quality of the curd
5th class designates the worst quality of the curd

Table 1b

Curd diameter cm			Curd weight g			Curd quality in classes[1]			Cv. code no.
N	$\bar{x}$	S	N	$\bar{x}$	S	N	$\bar{x}$	S	
32	5,2	0,63	32	20	0,00	32	4,7	0,55	1
31	5,1	0,37	31	21	7,30	31	4,9	0,37	2
73	12,9	3,31	73	70	46,90	69	2,0	0,24	3
40	13,7	3,87	41	80	46,90	18	2,0	0,49	4
47	14,2	3,61	47	183	100,30	46	1,3	0,92	5
107	13,8	6,42	107	187	187,33	107	2,0	0,86	6
130	20,6	5,90	129	384	167,98	129	1,2	0,96	7
34	5,2	0,70	35	27	16,80	35	4,5	0,69	8
31	6,0x	1,90	30	24	12,87	31	3,9	0,97	9
30	9,9	2,13	30	51	19,65	29	1,9	1,48	10
29	9,6	3,16	29	45	29,28	29	2,1	1,21	11
84	12,2	4,84	84	104	99,14	74	2,3	0,59	12
102	15,1xx	6,63	102	167xx	183,22	99	1,8xx	0,61	13
113	14,1	5,83	118	163	184,96	118	1,8	0,84	14
130	16,3xx	6,43	129	241xx	167,59	129	1,7xx	0,87	15
130	17,5	6,97	130	260	161,55	130	1,4	0,92	16
135	16,6	7,52	135	237	167,04	135	1,5	0,88	17

Sowing date 25.02.80
Sowing date in greenhouse 25.02.81
Planting date of the transplants in the field 5.05.80
Planting date of the transplants in the greenhouse 7.04.81
Space of the plants in the field 50 x 50 cm
Space of the plants in greenhouse 40 x 40 cm

HETEROSIS WITH SUMMER RAPESEED (Brassica napus L.)

M. LEFORT-BUSON

I - AIMS AND METHOD

Hybrid vigor has been tested for few summer hybrids in a little trial at the Plant Breeding Station of Rennes, in 1982. Five selfed lines from different locations have been crossed in a (5 x 5) diallel design. A 4 replication block design has been sown with 5-line plots 3,50 m long ; (the interline was of 0,30 m).

In this paper, only seed yield results are presented. Because of competition effects plot yield has been estimated with the 3 inner lines of each plot. Varietal effects have been tested in a 2-way analysis of variance, independantly for selfed-lines and hybrids ; for hybrids, a diallel analysis has been made with Griffing'method, in terms of general combining ability (G.C.A.), specific combining ability (S.C.A.) and reciprocal effects (R.E.).

II - RESULTS

Varietal effects are significant for both hybrids and selfed-lines. The error variances are not different one from another, but the differences between varieties are greater intra selfed lines than intra hybrids. Varietal means are given in table 1.

	Aburamasari	Mazowiecki	Nugget	Maris haplona	Cresor
Aburamasari	28,91	28,64	30,16	31,82	32,22
Mazowieki	28,68	23,30	25,81	25,70	30,09
Nugget	29,95	25,58	19,29	28,13	27,72
Marris haplona	31,45	24,73	27,28	24,08	29,83
Cresor	31,44	28,32	27,04	31,84	23,44

Rendement en qx/ha

Table 1 : Yield of the varieties

Concerning the 3 effects (G.C.A., S.C.A., R.E.), only G.C.A. effect is significantly different from 0. The G.C.A. of selfed "Aburamasari" (+2,30 qx/ha) and "Cresor" (+1,32 qx/ha) are significantly superior to the G.C.A. of "Nugget" (-1,48 qx/ha) and "Mazowiecki" (-2,17 qx/ha), Maris-haplona (+0,04 qx/ha) being intermediate.

The superiority of hybrids ($\hat{\mu}$ = 28,85 qx/ha) over selfed lines ($\hat{\mu}$ = 23,50 qx/ha) has been tested meaningly for all hybrids : it is significant when refered to the mean parent (5,05 ± 1,16 qx/ha) and to the best parent (3,02 ± 1,38 qx/ha) but few hybrids overyield the best line "Aburamasari" (Aburamasari x Haplona, Aburamarasi x Cresor).

CONCLUSION

These first results with summer hybrids have to be confirmed over years and locations, but it appears even now that, as for winter forms :

- hybrid varieties are interesting from an economical point of view ;
- the genic pool of the asiatic line "Aburamasari" ensure a good complementation with the genic pool of the other tested lines.

RUTABAGA AND CHINESE CABBAGE IMPROVEMENT

Shigemi Honma

Work on selecting desirable phenotypes of rutabaga with resistance to club root, was continued in cooperation with Canadian colleagues. Limited progress toward good root types have been made.

We have been interested in obtaining bolt resistant Chinese cabbage for the last few years (Proceedings 1st International Symposium on Chinese Cabbage, 1980; ppg 451-453.). Resistance is being derived from kale (Euphytica 9:243-246). Recent crosses with Chinese cabbage cultivars other than Mandarin which was used in the original cross have given only limited success. Genetic studies on bolt resistance is presently being conducted.

ESTIMATES OF HERITABILITY AND GAIN OF SELECTION OF TEN QUANTITATIVE CHARACTERS OF CHINESE HEAD CABBAGE, WITH DISCUSSION CONCERNING THE METHODS OF THE ESTIMATION OF BROAD HERITABILITY.

Tan Qimeng, Zhao Guoyu, Wei Yutang, Lee Baojiang.

Abstract

Two cross combinations, each with six population lines, of Chinese head cabbage were used to estimate the heritabilities and gains of selection of ten quantitative characters. The following are results obtained in this experiment. The percentages of narrow heritability in the two crosses are quite similar for most characters except that of leaf number per head and disease resistance. The narrow heritabilities of plant diameter, head firmness, and plant height are larger (around 50%) than that of leaf differentiation rate, head diameter, leaf number per plant, gross weight and net weight (around 30%). The influence of genetic coefficient of variation of a character on its expected gain of selection is greater than that of the heritability under the same intensity of selection. Since the heritability, the genetic coefficient of variation and the expected gain of selection of the F_2 population of these characters are mostly larger than that of the back cross population, it ought to be generally more effective to select within F_2 population than within back cross population, only except that the mean of the back cross population is significantly larger than that of the F_2 population.

The percentages of broad heritability estimated by using the $h_B^2 = \frac{V_{F2} - \frac{1}{2}(V_{P1} + V_{P2})}{V_{F2}}$ or $h_B^2 = \frac{V_{F2} - V_{F1}}{V_{F2}}$ formula appear in some characters to have magnitude smaller than their percentages of narrow heritability which implies that the Ve of F_2 thus estimated seems to be too large. On the other hand, the percentage of dominance calculated on the basis of such formula result with overdominant characters 7 out of 10 in A cross and 5 out of 10 in B cross. It is hard to believe that

there are really over half characters having overdominant gene effect, and this implies that the Ve of F_2 thus estimated seems to be too small. Thus, it can be predicted that the above one or two unreliable phenomena will still be encountered if the $\frac{V_{F2} - \frac{1}{3}(V_{P1} + V_{P2} + V_{F1})}{V_{F2}}$ or $\frac{V_{F2} - \sqrt[3]{V_{P1} \cdot V_{P2} \cdot V_{F1}}}{V_{F2}}$ formula be used to estimate the h_B^2. It is postulated that the above inconsistency is resulted from the use of phenotypic variances of different populations in the estimation of h_B^2 and h_N^2, because the populational differences in response to environment are variable in different characters and the ratio of $V_{F2}:V_B$ of these 10 characters may not perfectly correlated with their ratio of $V_{F2}:V_p$ or V_{F1}.

In order to get rid of such absurdity, an alternative method based on using the phenotypic variances of the same three populations (i.e. V_{F2}, V_{BP1} and V_{BP2}) in the estimation of both h_B^2 and h_N^2 is here proposed. Where the h_B^2 is estimated by the formula $h_B^2 = \frac{\frac{1}{2}V_A + \frac{1}{4}V_D}{V_{F_2}}$ instead of any formula using V_{p1}, V_{p2}, V_{F1}, and the $\frac{1}{4}V_D$ is deduced from the formula $\sqrt{V_A} \cdot \sqrt{V_D} = V_{BP2} - V_{BP1}$. The data thus obtained reveal that about half of the phenotypic variation of plant diameter, head firmness, plant height, leaf number per head and disease resistance among F_2 plants is cause by genotypic difference, while the phenotypic variation of head diameter, plant net weight and the remaining three characters is caused mainly by environmental influence. The genetic variance of the above five characters and of the head diameter is caused mainly by additional gene effects. The remaining four characters manifest greater dominant effect, but none of them shows overdominance.

CYTOPLASMIC MALE STERILE *BRASSICA CAMPESTRIS* BREEDING LINES WITH RESISTANCE TO CLUBROOT, TURNIP MOSAIC, AND DOWNY MILDEW

Hei Leung and Paul H. Williams

We have exploited the rigid pollen control provided by the Ogura's R1 cms system to develop Oriental brassica vegetables with multiple disease resistance to clubroot, downy mildew, and turnip mosaic. Four major morphotypes of *Brassica campestris*: ssp. *pekinensis* (Chinese cabbage), ssp. *chinensis* (pak choy), ssp. *narinosa* (rugosa type), and ssp. *rapa* (turnip) were bred into the R1 cytoplasm. Sources of the male recurrent parents were USDA PI accessions, local cultivars, and breeding lines from the People's Republic of China and the Asian Vegetable Research and Development Center, Taiwan.

Screening and selection for resistance to clubroot, turnip mosaic, and downy mildew were carried out using the pathogenic strains *Plasmodiophora brassica* Wor. race 6 (PHW-526), TuMV C_1 strain (PHW-559), and a *Peronospora parasitica* (Pers) ex. Fr. isolate (PHW-558) collected from Chinese cabbage in Taiwan in 1980.

After three cycles of repeated backcrossing and selection, seeds of five lines of *B. campestris* ssp. *pekinensis*, two lines of *B. campestris* ssp. *chinensis*, one line of *B. campestris* ssp. *narinosa*, and one line of *B. campestris* ssp. *rapa* are now available to private and public researchers. Each line is a half-sib family resulting from crossing a cms parent with bulked pollen from 4-5 plants of a male line.

The level of resistance to the three diseases varies among lines of different parentage. About 50% of plants in all lines are clubroot resistant. Percentages of plants resistant to TuMV and downy mildew range between 30-90% and 10-80% respectively.

Horticultural characters such as heading character, seed yield, and nectary development have responsed favorably to selection, and further gains can be expected. The major obstacle remaining is the R1 cms-associated seedling and cold temperature chlorosis. We have not succeeded in stabilizing the trait over four cycles of selection. The problem of chlorosis needs to be resolved before the R1 cms *B. campestris* becomes useful in commercial hybrid production.

USE OF THE RAPID-CYCLING BRASSICA CAMPESTRIS POPULATION, CGS-1, FOR TEACHING PRINCIPLES OF QUANTITATIVE GENETICS

Marlin Edwards, Tom Osborn, and Paul H. Williams

Students in an intermediate-level plant breeding course at the University of Wisconsin conducted an exercise in the spring of 1982 with the rapid-cycling population of Brassica campestris, CGS-1, which provided exposure to basic principles of quantitative genetics and selection for quantitative traits. The project investigated the genetic control of yield and components of yield in a heterogeneous population of B. campestris, CGS-1 (PHW-Aaa-1), which had previously been selected for rapid generation time.

The specific objectives of the project were to:

1. examine phenotypic correlations between yield (total seed weight) and selected components of yield (pod number, seeds/ pod, and weight/seed),
2. estimate genetic correlations between yield and yield components,
3. estimate narrow-sense heritabilities for each of the traits based upon each of two methods:
    a) covariance among half-sibs,
    b) parent-offspring regression,
4. measure gain from two cycles of selection for each of the yield components (and yield itself) from the same base population,
5. determine "realized" heritability for each trait,
6. measure correlated responses to selection.

The CGS-1 population cycles in 40 days in a growth chamber, so two generations may be grown and evaluated within a 16-week course. In order to accomplish as much as possible within the course, the first generation was scheduled and planted to be mature at the beginning. This allowed evaluation and two further generations to be grown and evaluated by the class.

Because of the importance of thorough hand-pollination and the extensive quantitative evaluations of traits required for each individual, this project is rather laborious. However, with a class of 15-25 students, the necessary tasks may be distributed to require only a moderate amount of time from each student. Dependent upon the computing facilities available, students may individually analyze the raw data collected by the class and stored in computer memory or, alternatively, summary statistics may be distributed for individual interpretation.

Quantitative genetics is a subject which is difficult for many students. This difficulty is, in part, due to the abstracted mathmatical and statistical procedures involved. By working with a population of plants and toward objectives typical of those often pursued in plant breeding, many students find the subject more tenable and interesting. The rapid-cycling population, CGS-1 of B. campestris may provide an ideal exposure for teaching objectives in quantitative genetics because of the limited space and time required for studies which would require large land areas and perhaps years in other crops. This particular project is just one of many which might be undertaken with this stock.

Copies of a more detailed procedural outline and the results obtained from this exercise are available upon request.

SELECTION AND GENETICS OF NECTARY DEVELOPMENT IN CYTOPLASMIC MALE STERILE *BRASSICA CAMPESTRIS*

Hei Leung, Xin-ke Niu, and Paul H. Williams

The discovery of cytoplasmic male sterility in radish (R1 cytoplasm) by Ogura has provided an alternative approach to the self-incompatibility system in hybrid brassica production. Through nuclear substitution various R1cms *Brassica* species have been generated. Though R1cms brassicas are environmentally stable, several physiological and morphological abnormalities associated with the R1 cytoplasm can limit the potential usefulness of the R1cms system in commercial seed production. One of the major abnormalities is a partial to complete suppression of nectary development in the cms parents that will lead to inadequate pollination in the field. We have approached the problem of insect pollination in R1 cms *B. campestris* by initially selecting for the number and size of nectaries to provide a morphological basis for further improvement of other nectary functions, such as nectar quantity, flavor, and aroma. Cytosterile *B. campestris* ssp. *pekinensis* (Chinese cabbage) and *B. campestris* ssp. *chinensis* (pak choy) were used in our selection and genetic study of nectary development.

Selection for nectary development was done using a 0 to 9 scale based on the number and size of nectaries with scale 9 representing full development. Plants with high nectary ratings were selected for further backcrossing. After three cycles of selection we have developed families having at least two nectaries of size comparable to normal and occasionally there are plants with four well-developed nectaries. A survey of the change in the average nectary development of backcross families in three pedigrees suggested that the recovery of nectary development was favored by certain genotypic combinations.

In order to see whether nectaries of cms plants were structurally and functionally similar to normal nectaries, nectaries of normal and cms plants were examined using light and scanning electron microscopy. Well-developed nectaries of cms plants were usually associated with nectar secretion and no anatomical differences between nectaries of normal and cms plants were apparent under the scanning electron microscope.

As for our genetic study, we used a half-sib family analysis to partition the phenotypic variance of nectary development into genetic and environmental components. Twenty-two plants randomly chosen from cms *B. campestris* backcross generations were crossed to two *B. campestris* pollen donors with normal nectaries. Nectary morphology of 20 progenies from each of the 44 crosses were scored and the variance components analysed. We have found negligible additive genetic variance (V_A)and variance due to dominance (V_D) and environment ($V_{EC} + V_{EW}$) constitute all the phenotypic variance estimated (Table 1).

Table 1. Estimates of variance components of half-sib family analysis of nectary development in cytoplasmic male sterile Brassica campestris.

Source	Component observational	Component causal	Estimate	Percent
Male	σ^2_n	$1/4V_A$	0	0
Female	$\sigma^2_{f/m}$	$1/4V_A + 1/4V_D + V_{EC}$	1.78	48.5
Progeny	σ^2_w	$1/2V_A + 3/4V_D + V_{EW}$	1.89	51.5
Total	σ^2_T	$V_A + V_D + V_{EC} + V_{EW}$	3.67	100

V_A = additive genetic variance
V_D = dominance genetic variance
V_{EC} = environmental variance due to common environment
V_{EW} = environmental variance within progeny

Though the effects due to dominance and common environment are confounded in the present design the significant female effect is likely due largely to maternal effects, which represents the common environment, rather than to dominance. This interpretation seems logical since the suppression of nectary development is an R1 cms-associated trait in B. campestris, and may be subject to a substantial cytoplasmic influence. It is unlikely however that nectary development is entirely controlled by the R1 cytoplasm, as gain through selection would be impossible in the absence of cytoplasmic diversity. The improvement of nectary development in the breeding population and the differential response to selection observed in different pedigrees suggest considerable cytoplasmic nuclear interaction. By crossing the lines with partially restored nectary function to a wide range of male genotypes one should be able to generate diverse cytoplasmic-nuclear interactions which would permit further improvement of nectary function.

RAPID-CYCLING POPULATIONS OF BRASSICA AND RAPHANUS SPECIES FOR GENETIC STUDIES

Paul H. Williams and Curtis B. Hill

Over the past 10 years we have been involved in the development of rapid-cycling crucifer populations which could be used to facilitate basic genetic studies of Brassica campestris (Aaa), B. nigra (Bbb), B. oleracea (Ccc), B. juncea (ABaabb), B. napus (ACaacc), B. carinata (BCbbcc) and Raphanus sativus (Rrr). Criteria used in selection of populations have been: 1) minimum time from sowing to flowering, 2) rapid seed maturation, 3) absence of seed dormancy, 4) petite plant habit and 5) high female fertility. Populations were derived initially by combining diverse early flowering types within each species, followed by recurrent mass selection in which the above selection criteria were used. Reproduction of each population is carried out in 28 x 55 cm plastic multipot trays of 96 plants per tray. The growing medium is a 'peatlite' mix of one part moss peat and one part Vermiculite, irrigated with 0.5% Hoagland's solution. Plants are continuously irradiated with 250 $Em^{-2}s^{-1}$ from fluorescent lamps. Populations of approximately 300 plants were grown at each cycle and 10% selection exercised with respect to early flowering individuals. Selection on a population was discontinued when the reduction in mean days to flowering became essentially stabilized, and when greater than 50% of the population flowered within a 2 day period. Populations were then mass increased for use in genetic studies and designated as base populations. Stocks of the following base populations are available as the first offerings of the Crucifer Genetics Stock Center (CGSC).

Table 1. Stocks available from the Crucifer Genetics Stock Center.

CGS #	original stock #	species	days to flower	description
1	PHW-Aaa-1	B.campestris	16	base population
2	PHW-Bbb-1	B. nigra	18	base population
3	PHW-Ccc-1	B. oleracea	29	base population
4	PHW-ABaabb-1	B. juncea	20	base population
5	PHW-ACaacc-1	B. napus	26	base population
6	PHW-BCbbcc-1	B. carinata	28	base population
7	PHW-Rrr-1	R. sativus	19	base population
8	PHW-Rlaa-1	B. campestris	16	Rlcms, CGS-1
9	PHW-Rlcc-1	B. oleracea	--	Rlcms, CGS-3
10	PHW-Rlaacc-1	B. napus	--	Rlcms, CGS-5

B = Brassica, R = Raphanus

Characterization of the base populations is under way using phenological and phenotypic traits such as: 1) days from seeding to first flower, 2) plant height to the first flower, 3) pods per plant, 4) seeds per pod and 5) mean seed weight. Populations are being indexed initially for their interaction phenotype to selected pathotypes of Albugo candida, Peronospora parasitica, Plasmodiophora brassicae, Fusarium oxysporum and Leptosphaeria malculans (Phoma lingam). Publication of base population development and characterization is in preparation. The base population CGS-1 (PHW-Aaa-1) has been used in a number of studies reported from our research group in this CRUCIFERAE NEWSLETTER.

The nuclear genomes of CGS-1 through -7 are being substituted in R1 cms cytoplasm from R. sativus (Ogura), in B1 cms cytoplasm from B. nigra (Pearson) and AB1 cms cytoplasm from B. juncea (Anand). As these stocks approach homogeneity they will be made available through the CGSC. We are currently moving a number of gene markers and resistance genes into rapid cycling backgrounds of various species. These stocks also will be listed and made available when appropriate quantities of seed have been produced.

Those wishing seed of the CGS stocks should write Paul H. Williams, Department of Plant Pathology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706.

SIZE OF ANEUPLOID POLLEN AND A MICROCOMPUTER-BASED MEASUREMENT SYSTEM

A. B. Wills and P. Smith

The determination of the gametic transmission rates of trisomic chromosomes is necessary for our investigations of trisomics of Brassica oleracea. Accurate chromosome counts in segregating families are laborious, and morphological characters in the families examined so far have not provided a basis for discriminating trisomic from disomic plants. Therefore we examined some pollen characteristics to discover whether the presence of additional chromosomes in pollen of aneuploid plants might cause recognisable differences in the diameter, variability, or viability of the pollen grains.

For this method to give a useful reduction in effort compared with that needed for chromosome counts it was necessary to minimise the labour of recording and analysis by use of a microcomputer-based measurement system. The equipment used comprised a microscope with a horizontal drawing arm, together with a Tektronix 4051 microcomputer and a Summagraphics digitising tablet and cursor. The cursor was fitted with fibre optics from a cold light source, producing a point of light that was superimposed via the horizontal drawing arm onto the microscope image of the slide. Measurements were made at 630x magnification using a cursor button to mark appropriate points, the position being measured by magnetoconstrictive ranging to an accuracy of 0.1 mm. Viability counts were made at 125x magnification and were also recorded by cursor buttons. The

microcomputer was programmed to determine the cursor coordinates, and then to calculate pollen grain diameter and various statistics. The measurements were recorded on magnetic tape and subsequently displayed as a histogram on a storage-type visual display unit.

Flowers were collected after anthesis from 2n, 2n+1, 2n+2, 3n-2, 3n-1, 3n and 4n plants, as well as from some with unknown chromosome numbers. Pollen was stained on slides in aceto-carmine jelly. Viable grains took up the stain over several hours and became swollen to a nearly spherical shape, while inviable grains remained shrunken and unstained. The maximum diameters of 100 viable grains were measured from random transects on each slide, and viable and inviable grains counted in five random fields.

Pollen grain diameter was approximately normally distributed, the mean and median being very close for each plant. No plant gave a clearly bimodal distribution. The mean diameters for 2n, 3n and 4n plants fell into separate ranges with very little overlap. The mean diameters and their standard deviations for 2n+1 and 2n+2 plants were within the range recorded for 2n plants; similarly 3n-2 and 3n-1 plants fell within the 3n range. The proportion of inviable grains in diploid plants, which were all siblings of the aneuploids, varied from 3 to 39 per cent. This range was exceeded by only one aneuploid among plants with known chromosome number.

Mean pollen diameter could readily distinguish between 2n, 3n and 4n plants, as expected, but aneuploids were classified with the nearest euploid group and were indistinguishable from them. Combination of various statistics, for example the graph of standard deviation against the proportion of unstained pollen, resulted in no obvious improvement in discrimination.

The method of measurement using a microscope and digitising tablet was particularly efficient, allowing the recording of 100 diameters in about 10 minutes and of 100 pollen grain perimeters or areas in about 25 minutes. The required measurements, statistics and histograms were produced directly by the microcomputer. The system would be very useful for routine pollen measurements and could be used to investigate whether alternative methods of pollen preparation, or dry pollen, would achieve the required discrimination.

LEAFY FODDER BRASSICA HYBRIDS AND FORMS IN THE BRASSICA SPECIES COLLECTION

W. Młyniec, E. Röhm-Rodowald, K. Zielińska

The need for plants suitable for catch crop cultivation in Poland is the main reason for evaluation of our Brassica collection and of hybrids obtained by interspecific crosses within the genus Brassica. Intensity and vigour of vegetative growth in autumn, and in spring, and winterhardiness, were the main criteria of the first stage of evaluation.

Chinese cabbage (B. campestris ssp. pekinensis) cvs. representing many desirable characters were not winterhardy. However, when used as parental forms for crossing they introduced intensity and vigour of vegetative growth into hybrids (Cruciferae Newsletter, No. 6, 1981, p.38).

All fodder kale (B. o. var. acephala) in our collection grew intensively and produced high green matter yields in autumn, but were not winterhardy enough. Cv. Normal was the male partner of our first B. napus synthetic form (Cruciferae Newsletter No. 6, 1981, p.36).

As winter catch crops, leafy fodder forms of B. napus var. biennis , seemed to be most interesting. Cvs differed much in winterhardiness. The most winterhardy cv. Siberian introduced winterhardiness into hybrids, but also unfavourable characters of slower vegetative and generative development.

Turnip rape (B.c. ssp. oleifera) cvs differing much in intensity and vigour of vegetative growth in autumn and in spring, in general were very winterhardy. Cvs Pluto and Arctus were parental forms of the most valuable hybrids.

A large range of old traditional and new improved rape seed (B.n. var oleifera) cvs , some among them well adapted to Polish climatic and soil conditions, differed greatly in the characters of interest to us. They are rich sources of potential partners for our hybridization programme.

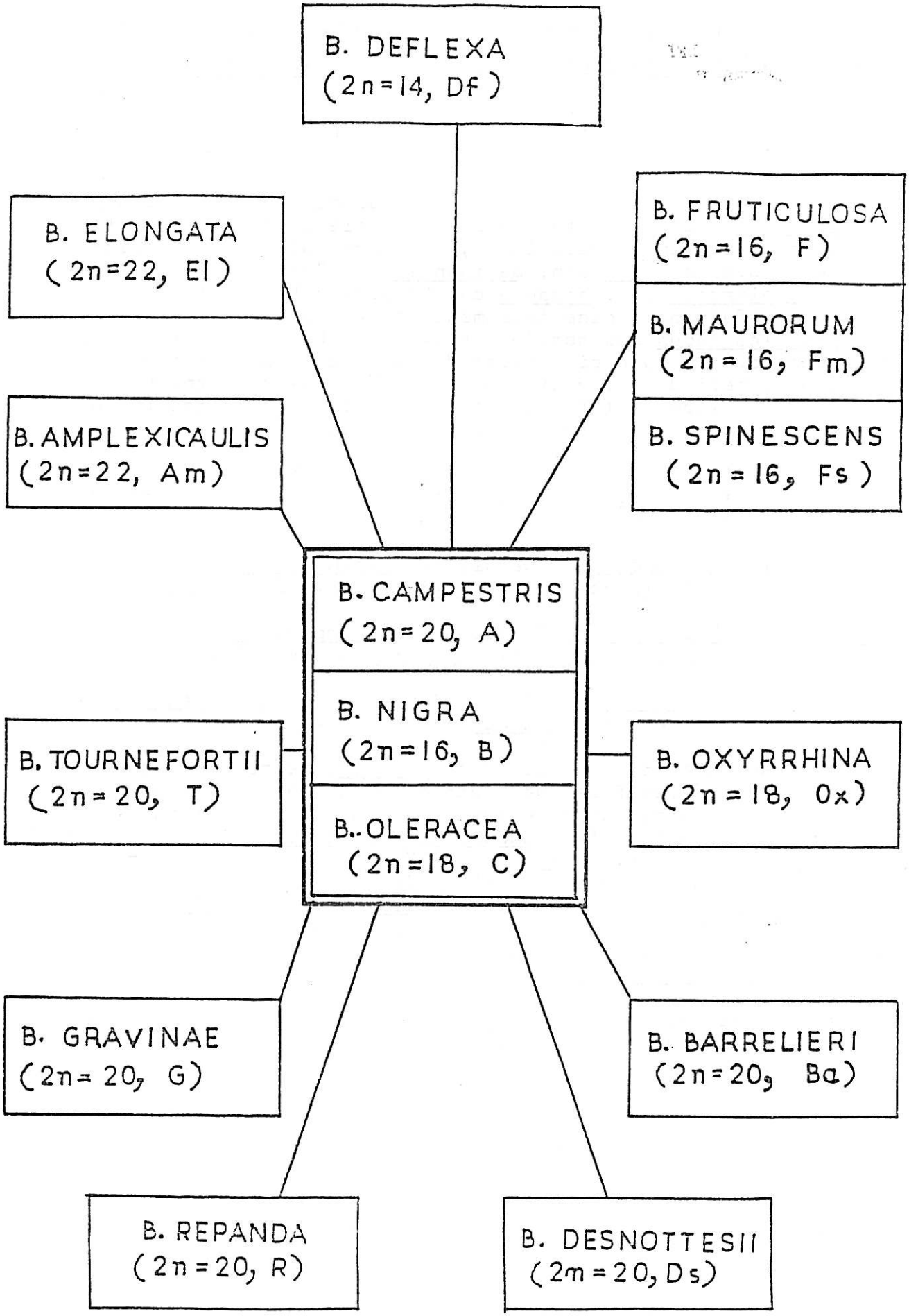
INTERSPECIFIC HYBRIDIZATION INVOLVING WILD AND CULTIVATED GENOMES IN THE GENUS BRASSICA

Shyam Prakash, S.Tsunoda, R. N. Raut & Sarla Gupta

Wild species constitute a good number in the genus Brassica. Distributed mostly around Mediterranean, they have various chromosome numbers and different genomes. To understand their cytogenetical relationships with crop Brassicas and to transfer desirable attributes like resistance to aphids and Alternaria blight from wild species to basic genomes, a project on inter-specific hybridization was taken up in the year 1976 at Laboratory of Plant Breeding, Tohoku University, Sendai, Japan by the two senior authors (SP and ST). It was later continued at Indian Agricultural Research Institute, New Delhi. Various species along with their somatic chromosome numbers and genomes and the hybridization program are represented in the attached scheme. Hybrids were obtained either by hand pollinations or through ovary culturing. Several chemicals like α-amino caproic acid and n-Hexane were applied on stigmas before or after pollinations to overcome the incompatibility barriers. So far following amphidiploids have been obtained:

1. B. nigra X B. fruticulosa
2. B. nigra X B. spinescens
3. B. nigra X B. maurorum
4. B. barrlieri X B. nigra
5. B. tournefortii X B. nigra
6. B. oxyrrhina X B. nigra
7. B. campestris X B. fruticulosa
8. B. campestris X B. spinescens
9. B. oxyrrhina X B. campestris
10. B. barrelieri X B. campestris
11. B. campestris X B. maurorum
12. B. campestris X B. gravinae
13. B. tournefortii X B. campestris
14. B. tournefortii X B. oleracea
15. B. tournefortii X B. fruticulosa

These amphidiploids are being studied for their chromosome behaviour, fertility and reaction to pest and diseases. At the same time, amphidiploids are being made amongst wild species also.



SCHEME OF HYBRIDIZATION IN THE GENUS BRASSICA

INTERSPECIFIC HYBRIDISATION WITHIN THE GENUS *BRASSICA* BY *IN VITRO* CULTURE. I. ARTIFICIAL *BRASSICA NAPUS*

Elzbieta Zwierzykowska

In plant material from interspecific hybridisation by *in vitro* culture in the year 1980 there appeared 1 plant with chromosome number 2n=19, the parental forms of which were: *B.campestris* ssp. *pekinensis* cv. "Nagaoka WR 55 Days" x *B. oleracea* var. *sabauda* cv. "Predzvest". After successful colchicine treatment of this plant, artificial *Brassica napus* was obtained /2n=38/. F_2 progeny from the seeds of the colchcine treated shoot was observed during winter period in the greenhouse. The seeds of the F_3 progeny, from most fertile plants, were sown in the field this year to check their winterhardiness.

During the last vegetation period, there were obtained 18 plants by *in vitro* culture of immature embryos, from the following combinations:

1. *B.campestris* "Candle" x /*B.campestris* "Candle" x *B.oleracea* var. *gemmifera* 2n=19/ - 9 plants.
2. *B.campestris* "Candle" x /*B.campestris* "Torpe" x *B.oleracea* var. *sabellica* 4x 2n=28/ - 6 plants.
3. /*B.campestris* "Candle" x *B.oleracea* var.*sabellica* 4x 2n=28/ x *B.napus* "Regent" - 3 plants.

Among hybrids obtained by *in vitro* method during the past year /Cruciferae Newsletter No. 6 1981, p. 36-37/ there were found 6 plants with chromosome number 2n=19: 5 plants from combination of *B.campestris* ssp. *pekinensis* cv. "Granaat" x *B.oleracea* var. *capitata* cv. "Market Topper F_1", and one plant in the progeny of the combination *B.campestris* ssp. *pekinensis* "Chinese cabbage" x *B.oleracea* var. *capitata* cv. "Market Topper F_1". All these above mentioned plants were treated with colchicine aimed at obtaining artificial forms of *B.napus*.

Besides, during this year, there were made crossing, by conventional method, between different forms in the genus *Brassica*. Data dealing with results of these crosses are listed in Table 1.

Table 1. Results of crossings within the genus Brassica by conventional method.

Progeny	Maternal form \ Paternal form	Brassica campestris						B. napus			
		"Candle"		"Yellow sarson"		pekinen-sis x sarson		"Gulliver"		"Regent"	
		1*	2**	1	2	1	2	1	2	1	2
F_1	B. napus "Gulliver" x B. oleracea var. capitata 2n=28	135	15					285	486	289	815
	B. campestris "Granaat" x B. oleracea var. capitata 2n=28			190	2	250	-	150	-		
	B. campestris "Candle" x B. oleracea var. gemmifera 2n=19	33	4								
F_2	B. campestris "Candle" x B. oleracea var. sabellica 2n=28			170	4	190	4			177	4
	B. campestris"Torpe" x B. oleracea var. capitata 2n=28	150	6	160	10	150	17				
	B. campestris "Candle" x B. oleracea var. gemmifera 2n=19	150	-	130	-	170	-				

* 1 - number of pollinated flowers
** 2 - number of seeds

BRASSICA NAPUS - ITS SYNTHESIS AND PROSPECTS AS AN OILSEED CROP IN INDIA

Shyam Prakash and R.N. Raut

Rape seed or Brassica napus is not grown commercially in India. Attempts had been made to introduce exotic cultivars as an oilseed crop primarily for its being highly productive and having high degree of tolerance to aphids (Lipaphis erysimi Kalt.) and Alternaria blight which cause severe losses to seed yield. However, these efforts proved a failure as the exotic cultivars were found to be very late flowering leading to very poor or no seed set. Among several approaches to breed early types, a programme on articicial synthesis of B. napus was initiated at Indian Agricultural Research Institute, New Delhi in the year 1967-68 (Prakash, 1980). The major aim of the synthesis was to evolve oleiferous forms suitable to Indian conditions. This is the first attempt to introduce B. napus as an oilseed crop on a commercial scale in India.

Various strains of early indigenous constituemt parents viz. B. campestris ssp. oleifera var. brown sarson and B. oleracea var. botrytis (cauliflower) were successfully hybridized. On chromosome doubling, amphidiploids were obtained which had irregular meiosis in the initial gene rations. Besides amphidiploids were also obtained direct from F_1 hybrids which were of non-homologous recombinant origin between A and C genome chromosomes. The mechanism involved in their origin was meiotic restitution giving rise to normal egg (2n = 19) which doubled itself parthenogenetically resulting into 38-chromosome amphidiploids (see Prakash, 1973). There were 3 quadrivalents which persisted upto generation A2 besides univalents which appeared even in generation A5. Plants were highly pollen and seed sterile in the initial generations. A gradual improvement in chromosome pairing and fertility was noticed with the intensive selection for high fertility. The stabilization was achieved in generation A6 when it showed only 19 bivalents and full fertility. In advanced generation viz. from 12 onwards, various strains were evaluated for their agronomic potential. In such an yield trial in generation A16 during 1981-82, 5 strains performed outstandingly in respect of yield as shown below:

Strain	Length of main inflorescence (cm)	No. of pods on main branch	Yield potential	Maturity (days)
Na-12	90	98	26.0	141
Bo-15	117	110	26.0	147
Bo-54	95	81	28.1	155
Bo-55	88	82	23.8	146
Bo-57	87	82	24.7	152

One of the characteristic feature of synthetic strains was the length of main inflorescence (reached up to 117 cm)and the number of pods it bears (up to 116). Oil content in these strains varied from 37 to 39 per cent. As mentioned earlier, maturity of the crop is one of the important character for which the synthesis was aimed at. All the strains were either medium (140-149 days) or slightly late maturing (150-155 days) and were very similar to late B. juncea cultivars like Prakash and RLM-198, the two popular varieties. These strains fit exceedingly well in the cropping pattern of north-western India. Additionally, they possess high degree of tolerance to aphids and Alternaria blight.

The other lines of work which are in progress or will be taken up in future are as follows:

1. Making use of large variability of both the constituent parents to obtain a spectrum of variations.

2. Use of in vitro techniques to get high frequency of hybrids.

3 Exploitation of non-homologous recombination for getting physiological and morphological variants.

4. Hybridization between artificial amphidiploids and naturally occurring high yielding cultivars to generate further variability.

In view of the good potentiality of B. napus as an oilseed crop, efforts are being made to popularise it with Indian farmers.

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CROSS-COMPATIBILITY OF HAKURAN (ARTIFICIALLY SYNTHESIZED *BRASSICA NAPUS*) WITH *BRASSICA* VEGETABLES

H. YAMAGISHI and K. TAKAYANAGI

Genus *Brassica* includes various kinds of useful vegetable crops. However, interspecific crosses among them are usually very difficult. With the aid of embryo culture technique, interspecific hybrids between Chinese cabbage (*B. campestris*) and cabbage (*B. oleracea*) were efficiently produced by Nishi *et al.* (1959). Some of the amphidiploids in this cross (artificially synthesized *B. napus*) showed heading characteristics and were named 'Hakuran'. Besides the usefulness as a vegetable, Hakuran is expected to be useful as a bridge species in *Brassica* vegetables. In this report we describe the cross-compatibility of Hakuran with other *Brassica* species.

Materials used in the experiment are as follows.

Chinese cabbage cultivars; Matsushima-jun No. 2, Shimoyamachitose, Nozaki No. 2
Cabbage cultivars; Masago-sanki, Nozaki-natsumaki, Red acre
Mustard (*B. juncea*) cultivars; Hakarashina, Chirimen-hakarashina, Akaooba-takana
Hakuran inbred lines; C-6 and C-7 bred in VOCRS
Hybrid (Chinese cabbage x cabbage)
Hybrids (Hakuran x Chinese cabbage, cabbage, mustard)

Cross pollination among the materials was conducted with emasculation of bud. From thirteen to forty days after pollination, siliques were harvested for the examination of developmental stages of embryo.

In the cross combination within the same species, as the differences of crossability among parental varieties or lines were not so large, the results of interspecific crosses were shown as the totals for each species combination in Table 1.

Hakuran was compatible with Chinese cabbage (2.5 seeds per pollination) and mustard (about one seed per 4 pollinations), but nearly incompatible with cabbage (about one seed per 100 pollinations). In the crosses of F_1 (Chinese cabbage x cabbage) with Chinese cabbage or mustard, about two seeds per 100 pollinations were obtained. Contrastly, no hybrid seed was obtained with cabbage inspite of 400 pollinations.

Back crosses of Chinese cabbage to F_1 (Hakuran x Chinese cabbage) and Hakuran to F_1 (Hakuran x cabbage) were very easy. However by back cross of cabbage to F_1 (Hakuran x cabbage), only 0.2 seeds per 100 pollinations were obtained.

Cabbage was also almost incompatible with mustard although Chinese cabbage and Hakuran were compatible with it.

In the crosses between cabbage and Hakuran or F_1 (Hakuran x cabbage) hybrid embryos aborted in the torpedo or earlier stages. And in the cross between cabbage and mustard no embryo was found in any stages (Table 2).

From these results Hakuran is thought to be easily crossed with Chinese cabbage and mustard and usable as a bridge species in *Brassica* vegetables. In contrast, as interspecific crosses between cabbage and other *Brassica* species are very difficult, cabbage has a unique position concerning cross-compatibility relationship in *Brassica*. And these differences of compatibility are explained by the development of hybrid embryos in silique.

Table 1. Cross-compatibility among *Brassica* vegetables or hybrids

Cross combinations[a]	Parental genomes	No. of pollinations	No. of siliques per 100 pollinations	No. of seeds per 100 pollinations	No. of seeds per silique
Hak x Chi	AACC x AA	358	53.9	252.0	4.7
Hak x Cab	AACC x CC	542	0.7	0.9	1.3
Hak x Mus	AACC x AABB	422	16.6	23.0	1.4
F_1 (Cab x Chi) x Chi	AC x AA	677	1.9	1.9	1.0
F_1 (Cab x Chi) x Cab	AC x CC	387	0	0	0
F_1 (Cab x Chi) x Mus	AC x AABB	189	1.6	1.6	1.0
Chi x Mus	AA x AABB	498	18.1	50.0	2.8
Cab x Mus	CC x AABB	238	0.4	0.4	1.0
F_1 (Hak x Chi) x Chi	AAC x AA	830	34.6	58.0	2.1
F_1 (Hak x Cab) x Cab	ACC x CC	447	0.2	0.2	1.0
F_1 (Hak x Cab) x Hak	ACC x AACC	152	42.1	162.5	3.9
F_1 (Hak x Mus) x Hak	AABC x AACC	223	16.1	19.7	1.2

a Hak; Hakuran Chi; Chinese cabbage Cab; Cabbage Mus; Mustard

Table 2. Embryo development by interspecific crosses of *Brassica*

Cross combination	Days after pollination	No. of silique	No. of embryos in[a]				No. of embryos per silique
			GS	HS	TS	NM	
Hak x Chi	20	2	0	6	15	4	12.5
	30	3	0	1	0	38	13.0
Hak x Cab	13	3	3	2	0	0	1.7
	20	5	1	6	1	0	1.6
	30	8	0	3	1	0	0.5
F_1 (Hak x Cab) x Cab	20	3	9	0	0	0	3.0
	30	6	5	15	0	0	3.3
	40	2	2	2	0	0	2.0
Hak x Mus	20	3	0	9	3	0	4.0
	30	3	0	3	0	1	1.3
	35	5	0	0	0	1	0.2
Chi x Mus	20	4	1	0	0	6	1.8
	30	2	0	0	0	3	1.5
Cab x Mus	30	2	0	0	0	0	0
	35	3	0	0	0	0	0

a GS; globular stage HS; heart stage TS; torpedo stage NM; nearly matured stage

SOME FEATURES IN F_3 GENERATION OF SYNTHETIC *BRASSICA NAPUS*

Miroslawa Balicka

A synthetic form of *B.napus* obtained as the result of crosses between *B.campestris* ssp. *pekinensis* Granaat × *B.oleracea* ssp. *acephala* Normal has reached the F_3 generation. In this progeny, as in the F_2, it is possible to distinguish two types of plants representing maternal and paternal phenotypes.

During observations of plants from this progeny, special attention was paid to the plant fertility. Pollen viability of plants of the F_3 progeny was in general higher than in the F_2 progeny. More than 30% of the plants in the F_3 generation were characterized by highest pollen viability amounting to 90.3 - 97.8% and the lowest 51.0 - 63.7%, with the F_2 progeny correspondingly: 90.1 - 92.4% and 60.8 - 67.0%.

The ratio of pod number per plant to flower peduncles in the F_3 generation amounted to 57.7 - 89.6% for the plants of highest fertility, and for the plants which characterized themselves with the lowest fertility - 0.0 - 7.4%. In the F_2 progeny corresponding data were 2.5 - 47.8%.

Number of seeds per pod in the F_3 generation oscillated, the most fertile plants from 73.4 - 75.2% and the lowest corresponding value was 28.6%. In F_2 progeny the highest data were 73.4 - 75.2% and the lowest, 11.3%.

An analysis of glucosinolates content in the seed of the F_3 generation is foreseen because there is a possibility to find out forms with lower amount of these compounds. This useful character may be inherited from the maternal genotype.

RAPHANOBRASSICA IN RETROSPECT AND PROSPECT

I.H. McNaughton

The first sterile, intergeneric hybrid involving Raphanus and Brassica was reported in 1826. In 1927 the amphidiploid, Raphanobrassica (2n = 36, rrcc) was produced, following spontaneous chromosome doubling of hybrids between Raphanus sativus (2n = 18, rr, radish) and Brassica oleracea (2n = 18, cc, Brussels sprouts, cabbage and kohl-rabi : (Karpechenko, 1927), Raphanobrassica does not occur naturally.

In the forty year period, 1927 to 1967, Raphanobrassica (RB) has been synthesised several times. Detailed studies of morphology, anatomy, seed fertility and chromosome behaviour have been made. Although marked vigour of RB's was reported there has been virtually no attempt to exploit any agronomic potential.

In 1967 a programme was started at the Scottish Plant Breeding Station, now the Scottish Crop Research Institute (Pentlandfield), to synthesise RB as a possible new forage crop in the hope of combining the known disease resistance of fodder radish (an annual, prone to premature flowering) with the biennial habit and winter hardiness of kale. This programme was considered particularly important in view of the general disease susceptibility of fodder rape (B. napus ssp. oleifera). Soon afterwards the Swedish Seed Association, Svalöf and the Welsh Plant Breeding Station (WPBS) also started to investigate the potential of RB, as a green manure and as a forage crop respectively. All RB's, produced at Pentlandfield, were synthesised by direct hybridization of colchicine induced autotetraploids. The B. oleracea parents used in initial crosses were thousand-head kale (var. fruticosa), curly kale (var. fimbriata) and hybrids between these botanical varieties. More recently marrow-stem kale (var. acephala) has been used and such kales were the basis of RB's produced at Svalöf.

At Pentlandfield early generation RB's were highly sterile, in spite of good chromosome association, and varied in vigour, a number of plants being stunted, chlorotic and deformed (McNaughton, 1973). Similar results were obtained at Svalöf and very low seed fertility was also found in RB's produced at WPBS.

The following is a summary of information regarding the agronomic potential of RB in the UK:

Yield factors

Fresh weight. Yields of RB's have sometimes far exceeded rape and, in most cases, have been superior in replicated small plot experiments.

Dry matter content (percentage). This has been consistently lower than rape, thus counteracting high fresh weight yields.

Dry matter yield. A number of trials, notably those carried out at four sites in 1975, have shown that RB is capable of exceeding rape by as much as 20 per cent. During the period 1976-81, however, varying trial results were obtained, some supporting the 1975 data, in others yields were equal to rape or, on some instances, significantly inferior. In some of the latter instances lower plant populations of RB's could have had some influence on the results, poorer seed quality and germination than commercial rape cultivars being contributary factors.

From late sowing (early August) both RB's and rapes are clearly outyielded by Dutch stubble turnips (B. campestris ssp. rapifera).

RB's with marrow-stem kale in their parentage have not yet been critically evaluated but, on a visual basis, seem to have better yield potential than those of other derivation. This has been demonstrated at Svalöf where dry matter yield advantages over marrow-stem kale were apparent (Ellerström, personal communication).

Nutritional factors

Crude protein content (percentage). Values have been consistently on a par with rape control cultivars.

DOMD (in vitro digestibility). DOMD levels of RB are at an acceptably high level and very similar to rape.

Toxic factors

SMCO (S-methyl cysteine sulphoxide). Levels of SMCO, causing haemolytic anaemia in ruminant animals, have always been higher than rape, but not as high as in kale and other forms of B. oleracea.

SCN^- (the thiocyanate ion). Thiocyanate induces goitre. Levels of SCN^- in RB's have always been higher than rape, sometimes several-fold higher. The deleterious effect of SCN^- can be counteracted by the addition of iodine to the diet. Other glucosinolates, such as progoitrin, have an irreversible reaction and may be more important, levels of these are currently being investigated.

Grazing trials

The ultimate criterion in the evaluation of a forage crop is its effect on animal production.

A few forms of RB have been included in field scale grazing experiments with lambs, generally in comparison with the rape cultivar, Lair. There has been evidence that lambs prefer rape to RB and that there may be greater wastage, especially of leaves, when grazing the latter crop. Rape has proved superior overall to RB as a fattening crop. At best similar results have been achieved for the two crops. Where lamb carcass quality has been evaluated, similar, satisfactory results have been obtained for rape and RB.

In spite of restriction of the animals to single crop diets, with no supplementation, there were no instances of serious deleterious effects of toxic factors during these trials.

Winter hardiness

RB's normally survive the winter in the UK, but may suffer some frost damage. Very high mortality occurred, however, during the very severe winters of 1978-79 and 1981-82, seasons which also had drastic effects on traditional forage brassica crops. In 1981-82, most widely spaced, transplanted RB plants survived whereas nearly all closely drilled plants were killed. RB's must be considered less winter hardy than forage rapes or kales but distinctly more biennial than fodder radish which has little frost resistance.

Seed fertility

Seed fertility, extremely low in early generations in which many plants were entirely sterile, has shown a gradual response to selection (mild inbreeding), but the best seed production on a field scale at Cambridge has been no more than about 20 per cent of an equivalent seed crop of rape. Conditions are not suitable for seed production in Scotland. Seed yield may be enhanced for RB in a warm dry climate, such as Spain, as opposed to a cold, wet one, such as Sweden (Ellerström, personal communication).

Seed extraction

Seed is difficult to extract mechanically from the apical, Raphanus like, part of the RB siliqua which is hard and indehiscent. This contains about 20 per cent of the total seed, the rest being readily extractable from the basal, Brassica like part, which is dehiscent. Toxopeus (in the Netherlands) reports easier seed extraction from siliquae of an RB line from Svalöf than from RB material from Pentlandfield.

Disease resistance

Plasmodiophora brassicae (causing club-root disease). RB's have shown resistance to virulent populations of P. brassicae, both in the field and in seedling tests carried out under controlled, glasshouse conditions. At best a very high level of resistance to a population giving an ECD 31/31/31 reaction, i.e. infecting all 15 differential hosts currently used for P. brassicae race typing, has been shown (McNaughton, 1979). Resistance to an inoculum which infected the most resistant differentials, ECD 02 and ECD 04, has also been demonstrated (Mattusch, personal communication). Some RB families have shown zero or very low disease indices in controlled tests against a population giving an ECD 21/31/31 reaction, i.e. infecting 13 of the 15 differentials, possibly the most virulent to be found in the UK. A number of other RB families were susceptible to this population however. ECD codings are sensu Buczacki et al (1975).

Erysiphe cruciferarum (Powdery mildew). Observations made at a number of trial sites from 1975-1981 have shown that RB's possess a high degree of tolerance or field resistance, the foliage seldom showing infection and giving zero or very low scores in comparison with rape cultivars which are generally susceptible. Inflorescences of RB plants, flowering prematurely in forage trials or grown for seed production, can be quite heavily infected however.

Peronospora parasitica (Downy mildew). In controlled laboratory tests, conducted at the University of Nottingham, seedlings of a number of RB families showed high resistance to one isolate (from oil-seed rape) and only slight sporulation when inoculated with another isolate (from cauliflower), controls being heavily infected (Kluczewski et al, 1980). RB resistance and rape susceptibility had earlier been reported for field grown plants at Cambridge (P.H. Williams, personal communication).

Nematode resistance

Heterodora schachtii (Sugar beet eelworm). Most cruciferous crops, and brassicas in particular, are susceptible to sugar beet eelworm, this has not favoured their inclusion in farm rotational systems that involve sugar beet, an important crop in Northern Europe. Experiments by H. Toxopeus in The Netherlands have demonstrated that RB's from Pentlandfield and from

Svalöf, possessed useful resistance and this has been improved to a high level of selection.

Future prospects

Introgression. There are various possible strategies for the introgression of genes, controlling desirable resistances from Raphanobrassica, or directly from Raphanus, into Brassica species. These strategies are too complex to detail here. Some of the hybridizations and backcrosses involved are known to be difficult, while others have yet to be attempted. Some may be facilitated by embryo, ovule or ovary culture. Protoplast fusion may prove useful in obtaining very difficult cross combinations. The fact remains, however, that, in order to achieve gene transfer, allosyndetic pairing between Brassica and Raphanus chromosomes must occur at some stage in any strategy. In view of preferntial pairing, this is likely to be a rare event.

Pollen irradiation. Gene transfer by pollen irradiation may be more feasible than introgression, in the above sense. The prerequisites for this technique are established since it is known that untreated Raphanus pollen will germinate on stigmas and pollen tubes travel down styles of three important crop species; B. campestris, B. napus and B. oleracea. True hybrids have been reported, but very rarely, from all three Brassica x Raphanus combinations.

In view of the deficiencies of Raphanobrassica, such as poor seed fertility and low dry matter content, it is considered that future work should be aimed at incorporating the valuable resistances of Raphanus into Brassica by introgression or by pollen irradiation, rather than persevering with the amphidiploid per se.

Several of the most advanced RB lines are being conserved in the Gene Bank at The National Vegetable Research Station, Wellesbourne.

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THE EFFECT OF EXOGENOUS ABSCISIC ACID (ABA) ON THE DEVELOPMENT OF CAULIFLOWER CURD EXPLANTS *IN VITRO*

Keith Wardle and Ivor Simpkins

As part of a wider study of biochemical and physiological changes associated with the production and transplantation of cauliflowers *in vitro*, curd explants from several cultivars were shake incubated in liquid, Linsmaier and Skoog's (1965) medium (8mg dm^{-3} IAA, 0.26mg dm^{-3} kinetin) in the presence of non-physiological concentrations of ABA.

Four varieties were tested, Currawong, Barrier Reef, St Gwithian and Pacific Talisman. Precise details for propagation were given in Wardle, Quinlan and Simpkins (1979).

Considerable differences were shown between the varieties with respect to the degree of organogenesis in the presence of concentrations of ABA up to 4mg dm^{-3}. Currawong showed uninhibited development up to 2mg dm^{-3} ABA whereas at 3mg dm^{-3} and above development of explants was retarded showing small, leaf surface primordia which failed to expand even after incubation periods of up to six weeks. When such explants were transferred to ABA free medium however, very rapid expansion ensued and after a further two weeks incubation these plantlets were more robust than untreated explants. Similar concentrations of exogenous ABA also slowed down the rate of growth of Barrier Reef explants but in this case did not reduce leaf size, instead causing the production of short (less than 10mm) swollen roots, covered with friable callus. This callus consisted of very large, highly vacuolate cells, packed with starch grains.

ABA did not affect plantlet morphology in either St Gwithian or Pacific Talisman, although the growth rate was slightly retarded. Pacific Talisman was unusual in that it did not form roots on prolonged incubation and even in the absence of ABA produced tightly packed, unexpanded leaves. Where morphological changes were produced in response to ABA a two- to three-fold increase was observed in the level of soluble amino acids.

In this preliminary study therefore, a range of morphological effects were produced in different cultivars in response to the single phytohormone, presumably due to the different rates of

uptake, metabolism or modes of interaction with other growth regulators. These observations suggest that tissue cultures of cauliflower would be useful for a comparative study of ABA utilisation *in vitro* and may also indicate a correlation between resistance to exogenous ABA and the capacity to produce different amounts of endogenous ABA as a drought stress response under field conditions.

Incorporation of ABA into medium prior to transplantation is not a practical means of improving survival of plantlets after transfer to soil and low humidity conditions however, because guard cells of leaves formed in culture are open and unresponsive to ABA (Wardle *et al.*, 1979) and in addition, cauliflower leaves produced in culture rapidly die back after transfer.

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IN VITRO GERMINATION OF BRASSICA OLERACEA POLLEN

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At the Scottish Crop Research Institute we have found that Brassica oleracea pollen germinates poorly in vitro in any of the published media tested (Kameya and Hinata, 1970; Chiang, 1974; Sedgely, 1974; Ferrari and Wallace, 1975; Kuo, Peng and Tsay, 1981). Germination on semi-solid agar media seldom exceeded 20% and in liquid culture (hanging drops, Darlington and LaCour, 1960) was less than 10%.

In the past we have tried many variations of both liquid and agar media with little success. Germination was not improved either by substituting other disaccharides for sucrose or by varying the concentrations of the micro-nutrients in the basic medium of Brewbaker and Kwack (1963). Varying the relative humidity or the agar concentration in semi-solid media also resulted in no significant improvement.

Recently we have re-examined the problem in order to use B. oleracea pollen in the TLC pollen bioassay technique (Hodgkin and Lyon, 1982). In one set of experiments some stimulation of germination was found in hanging drops when small amounts of alkali were added to the medium. Of the alkalis tested, 3.5 mM ammonia in solution gave the greatest improvement in germination. After 4 h incubation at 22°C germination percentages ranged from 45%-60% and pollen tube lengths reached 0.45 mm. Ammonium salts (NH_4Cl and NH_4NO_3) did not stimulate pollen germination and it seems likely that the improvement is due to the increased pH of the medium. This hypothesis is now being tested.

The pH of our distilled water is rather low (5.6-6.0) and the optimum ammonia concentration may vary depending on the distilled water used for the medium. Our best results have been obtained with the following germination medium:

0.585M sucrose, 2.54 mM $Ca(NO_3)_2$, 1.62 mM H_3BO_3, 0.99 mM KNO_3, 0.88 mM $MgSO_4.7H_2O$, 3.5 mM NH_3 in solution. This medium has pH 8.8 under our conditions.

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GLUCOSINOLATES IN ORIENTAL BRASSICA VEGETABLES

Curtis B. Hill, Paul H. Williams, Harvey L. Tookey,
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As part of a broader study of the glucosinolates (GS) in cruciferous vegetables, the contents of several cultivars of brassica vegetables from China and Japan were determined. Chinese cabbage, leafy morphotypes of B. campestris and B. juncea and turnip were represented.

Plants were grown in the field in Madison, Wisconsin during early summer. Edible portions were extracted in boiling methanol (VanEtten, et al., 1976). Total GS's were estimated by measuring glucose released after enzymatic hydrolysis of GS's (VanEtten and Daxenbichler, 1977). Individual GS's were estimated by different methods (Daxenbichler and VanEtten, 1977; Daxenbichler, et al., 1979; Josefsson, 1968).

B. juncea morphotypes had a predominance of allyl GS (351-745 ppm) which distinguished them from B. campestris. Chinese cultivars of Chinese cabbage (B. campestris ssp. pekinensis) were uniformly low in nearly all GS's. Some Japanese cultivars had up to 100 ppm of five-carbon GS's. Chinese cultivars of B. campestris ssp. chinensis had moderate levels of butenyl GS (100 ppm) and varying levels of pentenyl GS (trace - 60 ppm). Japanese Komatsuna and Shirona types of B. campestris had up to 229 ppm butenyl and up to 70 ppm pentenyl GS's. B. campestris ssp. nipposinica, a morphotype with deeply lobed foliage, had 100 ppm butenyl GS and was low in most others. Turnip roots (B. campestris ssp. rapifera) had a predominance of butenyl (28 ppm), phenylethyl (43 ppm) and indolyl (122 ppm) GS's. Turnip root cortical peelings and tops had significantly lower levels of methylthiobutyl and methylthiopentyl GS's than peeled roots but had higher levels of butenyl and total GS's. Both 2 - phenylethyl and 3 - indolylmethyl GS's were concentrated in the cortical peelings (Carlson, et al., 1982).

Currently the glucosinolates in several types of radishes (Raphanus sativus) and in forage raphanobrassicas are being evaluated.

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GENETICS OF GLUCOSINOLATES IN CRUCIFERS

Curtis B. Hill, Paul H. Williams, Diana G. Carlson, and Harvey L. Tookey

A study of the genetics of total and individual glucosinolates (GS) in six species of Brassica and Raphanus sativus is underway using annual crop forms and rapid-cycling stocks. Plants are sampled when the first flowers open. Methods of GS extraction and analyses are similar to those previously reported (see Glucosinolates in Oriental Brassica Vegetables in this NEWSLETTER).

In B. campestris, high GS stocks ranged from 776-2515 ppm per plant and low stocks ranged from 29-171 ppm. Data are collected from populations of 10-30 plants. Individual families in the F_1, F_3 amd BC_1 generations will be analyzed.

In B. oleracea, individual plants from the rapid-cycling stock PHW-Ccc-1 have been identified as high (275-418 ppm) or low (39-49 ppm) producers. Parentals are cloned to provide sufficient amounts of tissues for analyses. Eight parentals have been selfed and crossed in all possible combinations. Individual plants in the S_1, F_1, F_2 and BC_1 generations will be analyzed for total and individual GS's. Similar experiments with the other species of Brassica and R. sativus are planned.

Nuclear substitution stocks of the rapid-cycling B. campestris (PHW-Aaa-1), B. nigra (PHW-Bbb-1), B. oleracea (PHW-Ccc-1), B. juncea (PHW - ABaabb-1), B. carinata (PHW-BCbbcc-1), B. napus (PHW-ACaacc-1), and R. sativus (Rrr-1) are being developed in R1 (cms R. sativus), B1 (cms B. nigra) and AB1 (cms B. juncea) cytoplasms to ascertain the influence of cytoplasms on GS content.

THE GLUCOSINOLATE CONTENT OF LEAFY CRUCIFEROUS FODDER CROPS

J.E. Bradshaw, R.K. Heaney, G.R. Fenwick and I.H. McNaughton

In the United Kingdom the traditional leafy cruciferous fodder crops are marrow-stem kale (Brassica oleracea var. acephala) for autumn feeding of dairy cattle, thousand-head kale (B. oleracea var. fruticosa) for winter feeding of sheep and cattle, and fodder rape (B. napus ssp. oleifera) for autumn fattening of lambs. All three crops are commonly grazed in situ, and one of the animal disease problems associated with such grazing is goitre, including goitre in new-born lambs from ewes grazing thousand-head kale.

Goitrin and the thiocyanate ion are both goitrogens which are released, by enzyme hydrolysis, from glucosinolates, when cruciferous plants are crushed or macerated. The antithyroid effect of the thiocyanate ion, but not of goitrin, is overcome by adding iodine to the diet. Nevertheless, in the past, plant breeders have concentrated on selecting fodder rape, marrow-stem kale and thousand-head kale for low thiocyanate ion releasing glucosinolates, as rapid and reliable methods of chemical analysis were available. However, we found in a recent experiment that fodder rape, but not kale, had a particularly high progoitrin (the glucosinolate which releases goitrin) content and we have concluded that it is more important to select fodder rape, but not kale, for low progoitrin content.

The experiment included a selection of radicole (Raphanobrassica), an inter-generic hybrid which does not exist naturally. This hybrid between fodder radish (Raphanus sativus) and kale has been produced and evaluated as an alternative to fodder rape for fattening lambs. Its progoitrin content was lower than that of the rape cultivar Lair, but its glucobrassicin (the major thiocyanate ion releasing glucosinolate present) content was higher.

The detailed results of the experiment will soon be published and further work is in progress.

BREEDING FOR LOW SMCO AND LOW SCN^- CONTENTS IN FODDER KALE

J. E. Bradshaw and R. Borzucki

When kale is fed in large quantities to cattle and sheep they may develop severe haemolytic anaemia and also goitre. Therefore two important selection criteria in fodder kale breeding are lower contents of S-methyl cysteine sulphoxide (SMCO, the haemolytic factor) and of the thiocyanate ion (SCN^-, a goitrogen).

During 1980 and 1981 seven cultivars were grown in six replicated yield trials close to our research station near Edinburgh, Scotland. Trials 1 to 4 were sown between 10 May and 3 June into conventionally prepared seed beds on ploughed ground, whereas trials 5 and 6 were direct drilled between 18 June and 3 July into grass swards killed with gramoxone (this is now common practice after a first silage cut on grassland farms). Plants were harvested by cutting at ground level and were chopped in order to obtain representative samples for chemical analysis (Methods described by Allison, Cowe and Borzucki, 1980).

With trials and replicates within trials as random effects and cultivars as a fixed effect, the components of variation, scaled to sum to 100, were as follows:-

	Trials	Cultivars	Cultivars x trials	Replicates within trials	Plots (error)
SMCO	61.2	9.1	4.4	3.1	22.2
SCN^-	34.3	42.7	7.3	1.8	13.9

All sources of variation were statistically significant ($P < 0.05$) and the average coefficients of variation at the plot level were 16.2% and 16.9% for SMCO and SCN^- respectively.

The dry matter yields (DMY), crude protein (CP) and toxic factor contents of the dry matter (DM) for the six trials, averaged over the seven cultivars, were as follows:-

Trial	1	2	3	4	5	6
DMY(t/ha)	9.71	9.29	9.46	9.85	5.38	6.81
CP(g/kgDM)	135	154	141	142	189	140
SMCO(g/kgDM)	6.17	8.05	7.53	3.96	9.50	8.83
SCN^-(g/kgDM)	0.245	0.231	0.257	0.225	0.405	0.369

The SMCO and SCN^- contents (g/kgDM) of the seven cultivars (including selection KB21 from our kale polycross breeding programme), averaged over the six trials, were as follows:-

	Canson	Condor	Giganta	Kestrel	Merlin	Proteor	KB21
SMCO	9.10	6.83	6.89	7.76	6.93	7.04	6.83
SCN^-	0.455	0.220	0.213	0.265	0.222	0.315	0.332

Average standard errors of means: SMCO ±0.355; SCN^- ±0.0184

The dwarf thousand-head cultivar Canson had relatively high contents of both toxic factors whereas the marrow-stem cultivars, Condor, Giganta and Merlin, had relatively low contents. It may be possible to obtain even lower contents by intercrossing such cultivars.

As kale is a member of an outbreeding species, Brassica oleracea, and as the coefficients of variation for both toxic factors were relatively high, the best breeding method could be a population improvement scheme involving family selection. Comparisons of half-sib, full-sib and selfed families derived from our kale polycross breeding programme suggest that S_1 family selection may be the best scheme. With two replicates, 52% of the differences between the means of selfed families for SMCO was genetical and 75% for SCN^- was genetical. The range was from 5.75 to 9.50 g/kgDM for SMCO and from 0.113 to 0.438 g/kgDM for SCN^-.

Because of the large within plant variation for both toxic factors, we wondered if young leaves (approximately 15 cm long) might give better results than whole plants. Also it is much quicker and simpler to harvest 10 to 15 young leaves from a plot of kale than to chop whole plants in order to obtain a representative sample. However, whereas for nine cultivars there was a high correlation ($r = 0.84$) between young leaf and whole plant contents for SCN^-, there was only an intermediate correlation ($r = 0.71$) for SMCO. As low SMCO content is the more important breeding objective, we have doubts about using young leaves since differences between samples are not truly representative of the differences between whole plants.

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HARDNESS AND CHEMICAL COMPOSITION OF SWEDES

S. Gowers, R. Borzucki & D.J. Gemmell

Work on the selection of high dry matter swedes has resulted in the production of partially inbred lines with dry matter percentages considerably higher than the commercial cultivars from which they were derived. It is important to know how the chemical composition and hardness of the bulbs have been affected in these lines.

Dry matter percentages, soluble reducing sugars and S-methyl cysteine sulphoxide (SMCO) have been examined in lines derived from cultivars covering a wide range of dry matter contents. High, medium and low dry matter lines were selected from within these cultivars where this was possible. Samples were taken from two bulbs of each line at the beginning and end of the utilisation period and, with such small samples, the results should be viewed with caution.

Table 1. Dry matter content (DM%), soluble reducing sugars (SRS%) and s-methyl cysteine sulphoxide (SMCO) in swedes.

	Harvest date 14.9.81			Harvest date 29.3.82		
	DM%	SRS%	SMCO mg/g	DM%	SRS%	SMCO mg/g
BR a	14·9	36·5	5·4	10·4	41·5	5·8
b	14·4	19·9	5·9	12·1	38·1	5·6
c	12·0	24·7	5·4	10·9	41·5	5·7
EK a	12·7	35·4	6·5	11·9	42·3	5·1
b	12·0	39·2	5·2	10·6	39·9	5·0
c	12·3	41·0	4·7	11·0	42·7	6·0
BW a	16·0	31·5	6·0	12·1	39·7	5·1
b	17·2	28·0	6·9	12·4	40·3	5·3
c	17·4	36·7	4·9	11·8	36·3	4·4
CR a	12·0	37·5	5·0	11·5	49·7	4·7
b	11·7	40·3	4·0	10·1	52·3	3·6
BM a	12·2	33·4	5·1	11·2	47·2	4·6
BD a	14·9	32·2	5·6	11·8	45·1	6·6
Mean	13·8	33·6	5·4	11·5	42·8	5·2
%FWt		4·6	0·074		4·9	0·064

The dry matter percentages were determined on freeze-dried samples, which usually contain 10/12 per cent residual moisture. The dry matters determined in this way are therefore of the order of 2 per cent higher than oven dried samples.

Overall there is a general decrease in the dry matter percentages from September through to March. However, there is a dramatic decrease in the dry matter content of the high dry matter BW lines, especially in comparison with the low dry matter CR lines. These variations in time could have considerable effects on dry matter intakes and the efficient utilisation of these high dry matter lines.

Although SMCO does not appear to have been a problem with feeding swedes in the past, a high SMCO content in high dry matter lines could produce intake levels which affect animal performance. Estimation of SMCO is laborious, and the results suggest that the easier chemical determination of soluble sugars could produce a correlated decrease in SMCO levels.

Both the SMCO and sugar contents varied quite widely within and between cultivars. Improvements in these constituents appear to be possible, therefore, by selfing and selecting within the rather heterogeneous commercial cultivars presently available.

High dry matter is usually associated with winter hardiness, and the BW lines are indeed very winter hardy. However, the CR lines stood up well to the severe winter of 1981/82, especially CRb. With soluble sugar contents of 50-55 per cent, it is obvious that the depression of freezing point effect could greatly influence the frost resistance of such lines.

The hardness of high dry matter content lines could seriously influence intake levels, especially in the case of sheep where tooth loss appears to be a major factor. A preliminary examination of these aspects has been made using a penetrometer (SCRI Annual Report, 1982). From a trial involving partially inbred lines and their F_1 hybrids, there was a correlation of 0·86 between dry matter content and hardness. F_4 lines, however, only had a correlation of 0·6, indicating that high dry matter lines that are relatively soft could be selected.

A test of high dry matter SCRI lines with the top commercial cultivars produced some interesting comparisons (Table 2).

Table 2. Dry matter contents and hardness scores of SCRI lines and five top commercial cultivars. (Means of three bulbs over four replicates)

Cultivar	Dry matter percentage	Penetrometer reading (mm)
Ruta Otofte	10·4	57·3
Marian	10·1	54·5
Magres	10·8	51·8
Criffel	9·6	63·5
Sator Otofte	11·0	50·1
Angus	11·9	50·8
Melfort	12·0	54·3
SG430	13·9	45·3

The low dry matter Criffel and the high dry matter NLT entry SG430 show the range of hardness present in these lines. Comparisons of the new cultivars Angus and Melfort with the commercial cultivars show that, although higher in dry matter content, they do not appear any harder when tested with a penetrometer. Melfort, in fact, appears to be relatively soft in comparison to its dry matter content, being only as hard as the much lower dry matter content cultivar Marian. If the animals agree with these findings, Melfort should prove highly suitable for sheep as well as for cattle feed.

PROTEIN EVOLUTION DURING RIPENING IN WINTER, SUMMER AND F_2 RAPESEED

R. Voltan, G. Mosca, A.M. Olivieri

During ripening process crude protein, expressed as percentage of dry matter, generally decreases as other chemical components, first of all fiber, increase.

Variation in protein percentage is related to several factors such as genotype, part of plant, time of sampling. Here, data on the evolution of protein during seven weeks before harvesting time are reported for a winter variety (Primor), a summer one (Tower) and their combination in F_2 generation.

Rapeseed was sown on Oct. 2nd in replicated plots on a loam sandy soil at Padova (North-Eastern Italy). Beginning on May 5, when the crop was blossoming, percentage of protein was determinated every week keeping apart seed, empty pods, stems and leaves whose dry matter represents respectively about 18, 35, 6 and 35% of the entire plant.

Table 1 shows that protein percentage in seed does not change significantly during last month of cropping, supporting Ohlsson (1974) result. Primor and Tower, with about 20 and 25% of crude protein, were different between then, whereas F_2 was quite close to Primor.

In all other part of the plant protein percentage decreased as the maturity approached. At almost all sampling times F_2 showed the lowest values that, at a first sight, would be related to differences in earliness. However F_2 and Tower began to blossom respectively on April 7 and 8 and five days earlier than Primor, confirming dominance of summer types (Olivieri and Parrini, 1979). Therefore it seems that biochemical processes are faster in summer x winter F_2 combination than in parental types, indicating a certain heterosis at metabolic level.

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Table 1. Percentages of crude protein in Primor, Tower and F_2 Primor x Tower.

Samplig time	Seed			Empty pods			Leaves			Stems		
	Primor	Tower	P x T	Primor	Tower	P x T	Primor	Tower	P x T	Primor	Tower	P x T
May 5	-	-	-	-	-	-	26.7	24.5	25.5	13.0	10.4	8.9
13	-	-	-	-	-	-	23.0	21.8	21.5	8.3	9.7	6.9
20	19.8	25.2	21.8	13.0	17.2	13.6	21.3	20.8	21.9	7.4	7.0	5.5
26	22.7	24.1	22.3	11.7	14.7	10.9	13.1	15.8	12.1	6.1	5.2	3.7
June 2	21.0	24.7	20.2	10.1	13.3	8.5	16.1	14.2	16.1	5.6	4.5	3.0
9	19.4	24.7	21.3	8.0	9.0	7.8	15.2	14.1	14.0	5.4	3.2	2.9
16	20.3	26.0	21.8	5.9	7.8	5.6	13.3	-	13.1	3.2	3.1	3.3
23	21.5	26.3	22.5	5.4	5.6	5.1	12.4	-	-	3.0	3.3	3.0

MYROSINASE (THIOGLUCOSIDE GLUCOHYDROLASE) IN BRASSICAS

A. P. Wilkinson

Myrosinase (Thioglucoside Glucohydrolase, E.C. 3.2.1) catalyses the hydrolysis of glucosinolates, a group of sulphur-containing glycosides present in all Brassicas. The enzymically produced hydrolysis products contribute significantly to the flavour and aroma of Brassica vegetables but can have undesirable effects in animal feedstuffs. Previous investigations of myrosinase have used seeds as the enzyme source. Investigations have now been undertaken to determine the myrosinase activity in Brassica vegetables, with a view to improving the safety and quality of fresh and processed Brassica vegetables and feedstuffs.

Myrosinase activity in different Brassica species

The myrosinase activity, determined as the rate at which the glucosinolate sinigrin is hydrolysed, in the vegetative tissue of Cruciferae has been investigated. This experimentation demonstrated that activity differences between species are greater than activity differences between varieties of the same species. Myrosinase activity has also been shown to differ between cultivars of the same Brassica variety.

Myrosinase activity and the influence of ascorbic acid

Plant myrosinase activity is strongly activated by ascorbic acid. This property of the myrosinase enzyme makes its study of additional interest.

Previously published work has shown that the extent to which the enzyme is activated is dependent upon ascorbic acid concentration. Maximal enzymic activity occurs when the ascorbic acid concentration is 1mM, but increasing concentrations of ascorbic acid were shown to inhibit myrosinase activity so that 10mM ascorbic acid completely inhibited the enzyme. However, recent work has demonstrated that for all the Brassica vegetables so far investigated, the range of ascorbic acid concentrations over which myrosinase is active is considerably greater than previously reported for seed extracts. Maximal activity is still attained at about 1mM ascorbic acid, but at 10mM ascorbic acid, 60% of the maximal activity still remains and 50mM is required to completely inhibit myrosinase activity.

The above findings are of interest with regard to glucosinolate patterns and flavour of the different Brassica species as well as aiding cultivar identification. The effect of ascorbic acid is of interest because its concentration will have to be considered together with myrosinase activity in regard to flavour production.

THE POTENTIAL OF FORAGE BRASSICAS IN THE NORTHEASTERN UNITED STATES

Nathan Leonard

Brassicas have not been grown for forage in the United States for the last forty years except on a few farms. The farms that have grown forage crucifers have typically been part-time sheep operations with less than twenty animals. Even on these farms the area planted usually amounts to only a second crop off of a garden.

The importance of good quality, high yielding forages to the profitability of livestock operations has lead agronomists to investigate new forage crops. Recently there has been some interest in the forage brassicas. Several universities have conducted grazing trials with the crucifers and generally have concluded that they are economically unfeasible because perennial forage crops are more profitable.

However, many of the pastures in the Northeastern United States have severe site limitations which make conventional forage seedings impractical. These pastures typically have low levels of available phosphorus and are extremely acid. Because the sites are so rough, steep, or rocky fertilizer and lime cannot be tilled into the soil; surface applied lime and phosphorus penetrate the soil very slowly. No-tillage seedings are typically used on these sites but at least two seasons of fertility-building are necessary before a satisfactory perennial legume stand can be established.

During the fertility-building period lime and fertilizer do not substantially improve the yields or quality of the existing pasture plants. The question arises, then, if perennial forages are not suitable are there annual forage crops which can be profitably grown?

Researchers at the University of New Hampshire decided to address this question in 1980. Dr. David Koch, Dr. James Mitchell, and Dr. James Holter, research agronomist, extension agronomist, and animal scientist, respectively, developed a United States Department of Agriculture Small Farms project which is evaluating the use of several annual grasses and forage crucifers prior to the establishment of perennial forage crops. The author joined the project in 1981 as part of his Master's Degree program.

The forages considered for such a cropping program had to meet several criteria, first they had to substantially increase the amount of forage produced from the site, the species must produce most of their growth during periods when there is inadequate amounts of forage available, and last the species must be high quality. These criteria were decided on because the cost of establishing annual crops is high and must be out-weighed by the value of the forage produced.

Japanese millet, sudangrass, sorghum-sudangrass, corn, and a turnip x chinese cabbage hybrid (var. Tyfon) were chosen. The grasses are warm season annuals producing most of their growth during the hot summer period when cool season grasses and legumes do not produce well. The crucifer could, of course, supply forage through the autumn until snow cover, a period when only stored or purchased feeds are available in the Northeastern United States. All these crops are seeded no-till following herbicide treatments of glyphosate or paraquat.

During the first season of fertility-building Japanese millet consistently yields more than the other crops, therefore we have decided to use millet the first season on acid and infertile soils. A preliminary study indicates that sheep make better weight gains grazing on millet than on a good quality primarily white clover pasture. The sheep also prefer the millet to the clover.

A winter cover crop such as rye is suggested prior to the second season of annual cropping. With the soil a little less acid and the fertility improved the forage crucifers become the logical selection. The brassicas supply high yields of good quality feed late into the autumn when no other grazing is available. Tyfon planted on July 24, 1981, yielded 2.8 tons/hectare of dry matter from a September 11 harvest and the regrowth yielded another 2.4 tons/hectare on November 30. Unfortunately, root yield was not determined; the roots contribute substantially to the total yield. The first harvest's crude protein was 24 percent and the second harvest's was 16 percent.

We used Tyfon because of its quick regrowth habit after grazing and because it appears to have an allelopathic affect which greatly delays the germination of weeds the spring following the crop. Tyfon also leaves a near perfect seedbed for planting a perennial legume and grass mixture into. The allelopathy does not inhibit the establishment of a birdsfoot trefoil and timothy seeding, but actually seems to enhance it by suppressing the weed competition.

Certainly turnips, swedes, rape, and kale all have great potential and we will continue our species and variety trials. We have had no disease problems with the crucifers but have had to spray for flea beetles. Yields of 10 tons/hectare should be reasonable on the soils we are considering. Larger areas of forage crucifers will likely be planted in the Northeastern United States but it must be remembered that once soils are improved perennial forage crops are of more value. At the same time that forage crucifers lengthen the grazing season they also encourage farmers to renovate their pasture land.

Many agronomists in the United States hope to increase the area seeded to forage crucifers. We particularly look forward to receiving more information on the brassicas from agronomists in the United Kingdom and Europe.

SOURCES AND NATURE OF SEEDLING RESISTANCE TO DOWNY MILDEW AND TURNIP MOSAIC IN CHINESE CABBAGE (*BRASSICA CAMPESTRIS* ssp. *PEKINENSIS*)

Xin-ke Niu, Hei Leung, and Paul H. Williams

Downy mildew caused by *Peronospora parasitica* (Pers.) ex. Fr. and Turnip mosaic (TuMV) are two major diseases of Chinese cabbage. Limited information on sources and the nature of resistance to *P. parasitica* and TuMV and on pathotypic variation has generally deterred the use of host resistance. Though some local cultivars of Chinese cabbage presently grown in China show considerable resistance to both pathogens, the level and mode of resistance have not been fully investigated. We have undertaken a survey of seedling resistance to *P. parasitica* and TuMV in a range of Chinese cabbages collected from major production areas of China. In addition we have initiated studies on the inheritance of resistance to the two diseases.

Forty-six Chinese cabbage lines consisting of 19 open-pollinated cultivars, 21 inbreds, and six F_1 hybrids from North, Central, and South China were screened for seedling resistance to downy mildew and TuMV. The *P. parasitica* (PHW-640) and TuMV isolate (PHW-645) were collected from a Chinese cabbage field in Beijing, China in 1980. Of 46 lines tested for cotyledon resistance to *P. parasitica*, 10 lines were resistant, 15 lines showed heterogeneous response, and 21 lines were susceptible. Among the 37 lines tested for TuMV resistance, 24 lines were resistant, nine lines were heterogeneous, and four lines were susceptible. Five lines, Bau Chin 26. PHW-64707, PHW-64710, PHW-64722, and PHW-64620 showing dual resistance to *P. parasitica* and TuMV represent useful sources of resistance for breeding.

Resistance to *P. parasitica* at the cotyledon stage was expressed as a reduction in the sporulation capacity of the fungus. Segregation pattern of self, F_1, F_2, and testcross families suggested that downy mildew resistance was under dominant mongenic control.

Turnip mosaic resistance was expressed as a hypersensitive reaction. Analysis of F_1, F_2, and backcross progenies from a cross between resistant and susceptible parents suggested that resistance was conditioned by two dominant genes.

We have not addressed the issue of strain specificity of *P. parasitica* and TuMV. Whether the resistance identified in our study is strain specific is not known. In order to fully deploy host resistance in controlling downy mildew and turnip mosaic in Chinese cabbage, a comprehensive disease screening program involving a wide range of pathotypes is needed.

TWO NEW DISEASES OF CHINESE CABBAGE (BRASSICA PEKINENSIS (L.))

S.S. Karwasra and G.S. Saharan

During a general course of study in Nov.-Jan., 81 the authors observed two new diseases of Chinese cabbage, i.e. Downy mildew and Alternaria leaf spot caused by Peronospora parasitica (Pers.) de Bary and Alternaria brassicae (Berk) Sacc. These diseases were recorded at the experimental farm of Haryana Agricultural University, Hissar, India for the first time. The diseases have been observed to occur here for the last two years in mild to severe form.

(a) Downy mildew: The infected leaves were easily recognised by the presence of yellow flecks or patches on the upper surface. Examination of the lower surface revealed the presence of cottony greyishviolet mycelium intermingled with conidiophores and conidia on the corresponding areas, especially when humid conditions prevailed. Under dry weather conditions the yellow patches turned into necrotic areas of irregular size and shape with a light brown colour.

Pathogenicity was proved by inoculating a spore suspension onto fresh and healthy leaves. The conidiophores emerged through stomata in clusters, dichotomously branched, 128-160 um long, 12-20 um broad at their widest part, trunk thick, erect, bulbous at the base. Primary branches were spreading; secondary ones curved, interlocking; ultimate branchlets thick, sharp pointed, equal or acute angles, often curved back and hook-like near the tip, upto (32-48 um) long. Conidia were borne singly at the tip of each branchlet of the conidiophores, globose to sub-globose without difference between apex and base, contents slightly greyish brown, measuring 20-28 x 16-24 um.

(b) Alternaria leaf spot: This was another new disease in this crop noticed during the same period along with downy mildew. However, after January, Alternaria leaf spot was more predominant on the foliage.

The infected leaves were easily recognised by the presence of small, light-brown coloured areas which rapidly formed circular lesions from 0.5 cm to 1.0 cm in diameter. Concentric rings were also observed in the lesions. Sometimes lesions on the leaves increased in number and size and coalesced to form large irregular brown necrotic patches giving a blighting effect to the foliage on petioles, stem and seed pods. The spots were linear and dark brown to black in colour. Sporulation was enhanced when infected leaf bits were placed in a moist chamber.

The fungus was isolated on potato dextrose agar medium and pathogenicity was proved by putting the spore suspension onto fresh and healthy leaves. The conidiophores were olivaceous, septate branched, arose in fascicles and 36.0-52.0 x 4 um in size. The conidia were dark, obclavate, muriform, 125-203 x 31.2 um in size. The conidia were borne singly or in short chains with 8-10 transverse septa and few longitudinal septa.

INCIDENCE OF *ALTERNARIA* INFECTION IN OIL SEED RAPE *(BRASSICA NAPUS* L.) CROPS IN SCOTLAND

Kothanur P.R. Prasanna and J.H. Lennard

Oil seed rape *(Brassica napus)* is a relatively new crop in Scotland: in the 1970s the area increased to 280 hectares by 1976 but then declined. However, in 1981, interest in the crop was renewed and in 1982 1,752 hectares of winter oil seed rape, along with a further 170 hectares of spring crops were grown, mainly in east Scotland. In this year 40 crops, including two spring sowings, were assessed for the incidence of infection by *Alternaria* species which are recognised to present a major disease problem in this crop in England. Fields were sampled at two times, early July (flowering) and late August (seed filling): at the first stage 10 fields were found with infection and at the second period the number had increased to 32. Seed samples were taken from all crops and the results of standard blotter tests for *Alternaria* infection are given in Table 1 along with the regional location of the samples. Of the 40 samples, 80 per cent were found to be infected with *Alternaria brassicae* (Berk.) Sacc. The average percentage of seed infected was 4.2 but one sample showed 49 per cent infection. Infected seeds were discoloured and invariably failed to germinate.

Disease symptoms were expressed in the field in the form of leaf spotting, stem discolouration reduced plant size and pod spotting. When seed from spotted pods were plated out on V-8 agar and incubated, *A. brassicae* proved to be the major seed-borne fungus with an incidence up to as high as 89 per cent. Very few samples showed the presence of *Alternaria brassicicola* (Schw.) Wiltshire, *Sclerotinia* sp, *Phoma* sp, *Botrytis* sp, *Fusarium* sp, *Stemphyllium* sp, *Cladosporium* sp, *Alternaria alternata* (Fr.) Keissler, *Alternaria raphani* Groves and Skolko and *Alternaria tenuissima* (Kunze ex Pers.) Wiltshire.

The incidence of disease was greatest in the Border counties (Berwickshire and Roxburghshire) and tended to decline towards the north (Table 1). This might be associated with the trend towards warmer and wetter conditions in the south for much of the main growing season (Table 2), but also to the greater area of the crop grown in the Border counties. Also it is possible that residual sources of infection were greater in the south as a result of the cropping history of previous years.

Table 1 Incidence of *Alternaria brassicae* in crops of oil seed rape in south-east Scotland

District	Number of field samples	Number of samples in different percentage seed infection classes					
		0	1-5	6-10	11-15	16-20	21-50
Border	16	0	7	5	2	1	1
Lothian	9	2	5	2	0	0	0
Fife	7	2	2	3	0	0	0
Perth/Kinross	8	4	3	1	0	0	0
Total	40	8	17	11	2	1	1

Table 2 Monthly temperature and rainfall in south-east Scotland

District station	Daily mean temperature °C				Monthly rainfall mm			
	May	June	July	August	May	June	July	August
Border	11	13	15	15	40	131	35	38
Lothian	10	13	15	15	57	91	40	44
Fife	10	13	15	14	46	49	40	46
Perth/Kinross	9	13	14	-	36	38	25	59

A POPULATION IMPROVEMENT APPROACH FOR DEVELOPING RESISTANCE TO BLACKLEG IN RAPESEED

Neil Wratten and Gordon M. Murray

Rapeseed is a very useful complementary crop to wheat in rotations in the southern and central wheat belt of New South Wales. Starting in the late 1960s, the area sown to the crop reached a maximum of 33,000 hectares in 1971. It declined rapidly to only 508 hectares in 1976. Since then there has been a revival of interest coinciding with the release of better varietal types. Blackleg (*Leptosphaeria maculans*) was a major cause of the decline and it again threatens the future of the crop.

The breeding programme at Wagga Wagga commenced in 1973 and aims to develop cultivars combining high yield with desirable oil and meal quality and resistance to blackleg. Lines of *Brassica campestris, B. napus* and other *Brassica* spp. are routinely screened in field disease nurseries. Several sources of resistance to *L. maculans* have been identified. One line of *B. campestris* from this programme was released in 1982 as the cultivar Jumbuck.

Leptosphaeria maculans is highly variable. Isolates which vary in pathogenicity occur in Western Australia and new combinations of virulence genes were obtained by crossing these isolates (Cargeeg, 1980). This Western Australian work also demonstrated geographic variation between fungal populations; control of resistance in rape and pathogenicity in *L. maculans* was polygenic. We have found variability in cultural morphology for local isolates and indications of a similar geographical distribution of pathogen variability.

The polygenic nature of pathogenicity in the fungus, in combination with an effective annual sexual cycle in our environment, make it unlikely that resistance can be satisfactorily tested in the glasshouse. To overcome this problem, disease nurseries have been established at several locations. At each site single plants are selected for resistance to basal stem canker. By utilising cross-pollination, the different genes for resistance which these plants are expected to possess, and a recurrent selection system, highly variable plant populations can be developed and manipulated. In this way an equilibrium should be established between host and pathogen and yield loss through disease kept to a minimum. Contact with other workers in this field would be welcomed.

Cargeeg, L.A. (1980) - Host-pathogen relationships of the blackleg disease in rape (*Brassica napus* and *Brassica campestris*) caused by *Leptosphaeria maculans*. Ph. D. Thesis, University of Western Australia.

THE BLACK-LEG DISEASE: SOME ASPECTS OF THE HOST-PARASITE RELATIONSHIP

Georges Boudart

This paper is a summary of results concerning different aspects of the host-pathogen relationship (Leptosphaeria maculans/ Brassica ssp). I studied: biology of the fungus, etiology, ultrastructure, and physiology (s).

BIOLOGY: Sixteen fertile-combinations of 28 possible were obtained by mating eight monoascospore strains from an ascus of Leptosphaeria maculans indicating the bipolar nature of heterothalism. All asci contained 8 ascospores. Abnormal mitotic events occurred when a heterothallic cabbage isolate (mating type +) was crossed with a compatible isolate (mating type -) or with compatible monoascosporal strains. When grown on V_8 agar juice in the dark, the cabbage isolate (+) was phenotypically different from 16 other strains.

ETIOLOGY: In order to find a suitable susceptible host for ultrastructural and physiological studies, seedlings were grown under controlled environmental conditions.

Four cabbage cultivars and two winter rape cultivars, a very susceptible (Expander), and a resistant (R9) were inoculated at the cotyledonary stage by spraying a suspension of pycnidiospores (10^5/ml) of the cabbage isolate (+). Plants were grown at 14 and 24 C until the ninth leave stage. Disease severity was evaluated by following the development of cotyledonary lesions and hypocotyl necrosis. All cabbage seedlings were highly susceptible and more so than rape cv. Expander on which symptoms appeared later. A significant correlation was found at 14 C between the known susceptibility of nine other rape cultivars and their susceptibility to the cabbage isolate (+) by measuring the number of plants with cotyledonary lesions. Resistant genes in R9 were temperature sensitive. More necrosis developed at 24 C than at 14 C. Cotyledon and stem lesions developed differently when cabbage and rape cv. Expander seedlings were inoculated with the aggressive cabbage isolate or an aggressive monoascosporal strain isolated from naturally infected rape crops. Therefore it appears that at least two genes are implicated in symptom expression. Though specialization of Phoma isolates for their adapted hosts exists, we failed to find the high degree of specificity described by Delwiche and Williams (2).

ULTRASTRUCTURE: Ultrastructural studies in infected cabbage hypocotyls revealed: 1) conidia entered the plant directly through the stomata without germinating, 2) fungal growth was exclusively intercellular with numerous contact areas between hyphae and the cell walls, 3) organelle disorganization occurred a few days before cell wall lysis was apparent, 4) cell walls were progressively and extensively degraded, and 5) the fungus preferentially degraded pecto-hemicellulosic-rich regions of the cell walls.

PHYSIOLOGY: The fungus is known to produce a non-host-specific toxin, the sirodesmin, *in vitro* and *in vivo*. Previous results indicate there is no correlation between agressiveness of isolates and mutants and their ability to produce the toxin *in vitro*. When injected into cabbage hypocotyls the pure toxin did not produce typical necrosis. At 14 C resistant rape seedlings were highly sensitive to the toxin. Since Sacristan's work (3) does not agree with our results, the production of sirodesmin in infected hypocotyls and cotyledons is being examined.

Phytotoxic proteins are being characterized from culture filtrates of the fungus grown on a synthetic medium supplemented with a preparation of cabbage hypocotyl cell walls as a carbon source. Injection into crucifer hypocotyls of dialysed, concentrated culture filtrate containing greater than 0.5 µg of protein resulted in a heavy necrosis similar to that produced by the fungus. Further studies on the purification of the phytotoxic proteins are in progress.

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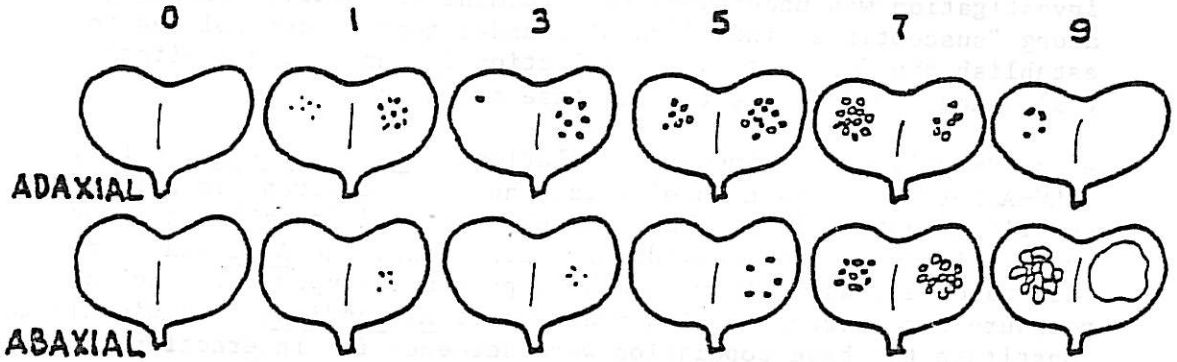
3. Sacristan, M.D.: 1982. Resistance responses to Phoma lingam of plants regenerated from selected cell and embryogenic cultures of haploid Brassica napus. Theor. Appl. Genet. 61: 193-200.

CORRELATION OF SPORE PRODUCTION BY ALBUGO CANDIDA ON BRASSICA CAMPESTRIS AND A VISUAL WHITE RUST RATING SCALE

David T. Fox and Paul H. Williams

Correlations of spore production by Albugo candida on B. campestris were made with a visual white rust interaction phenotype (IP) rating scale, in order to quantify selection for intermediate IP or partial resistance. The numerical 0-9 scale, rated plants according to amount of leaf necrosis or area covered by white rust pustules. (Figure 1).



If the visual ratings were correlated with spore production, a component of partial resistance, plant breeders could select for this type of resistance by using a simple visual rating instead of laborious leaf washings.

Brassica campestris stock CGS-1, (PHW-Aaa-1), was used as the host population. Each cotyledon of four-day-old seedlings was inoculated with two drops of a 10^5 zoospore/ml suspension of A. candida race 2. One week after inoculation, plants were visually evaluated as 1, 3, 5, 7, or 8 according to the rating scale size. Twenty cotyledons from each rating class were selected, weighed, and washed in 0.1% Tween 80. White rust pustules were ruptured with forceps during washing. Spore production was measured by counting the number of sporangia in eight samples of washing solution from each rating class. The experiment was repeated three times, and a two-way analysis of variance on the log-transformed data was performed.

In order to address the problem of spore deposition by highly sporulating plants onto their sparsely sporulating neighbors, spore production values from uninoculated control plants and inoculated pustule-free plants were compared. In each of three experiments, zero values were obtained from the control plants, while significantly higher non-zero values were obtained from the inoculated pustule-free plants. Therefore, it was concluded that spore production measurements were not confounded by extraneous spore deposition.

Spore production values on plants rated as 1, 3, 5, 7, and 8 were compared. Spore production was highly correlated with numerical rating based on visual assessment of disease ($r = 0.93$). In addition, means of spore production on plants rated as 1, 3, 5, and 7 were significantly different from each other. The significance of means supported the use of visual disease rating, a discrete variable, to approximate spore production, a continuous variable.

SELECTION FOR QUANTITATIVELY INHERITED RESISTANCE TO *ALBUGO CANDIDA* RACE 2 IN *BRASSICA CAMPESTRIS*, CGS-1

M. Edwards and P.H. Williams

Previous research with *B. campestris* has described a race-specific major gene *Ac-2* for immunity or low reaction type on cotyledons to white rust, *Albugo candida* race 2. Evaluation of heterogeneous populations of *Brassica campestris* reveals considerable variability in degree of reaction among susceptible genotypes when inoculated with *A. candida* race 2 under controlled conditions. This investigation was undertaken to determine if observed variability among "susceptible" individuals is under genetic control and to establish the degree to which selection for maximum quantitative resistance could reduce the response to infection.

A rapid-cycling experimental population of *B. campestris*, CGS-1, (PHW-Aaa-1) was chosen to minimize the time required for this genetic investigation. The procedure involved isolating a number of genetically variable individuals which lacked the *Ac-2* gene for resistance and using them as a base population upon which selection pressure was exerted for low reaction to *A. candida*. Individuals to constitute the base population were screened for interaction phenotype (IP) to *Albugo* on a scale of 0 to 9 (where 0 = immune and 9 = very susceptible) and self-pollinated to produce S_1 progeny which were also evaluated to confirm that they possessed no major genes for immunity. Thirty-six individuals, exhibiting highly-susceptible interactions when inoculated with *Albugo* were selected upon this basis. These individuals were mass-pollinated to produce progeny for selection.

Selection was exercised in two fashions for three succeeding generations. The first was simply mass selection of individuals with the lowest reaction to *Albugo*. Since individuals were assigned discrete values for reaction based upon their phenotype, there were often more individuals in the lowest class than required to formulate the 36 - individual base for the succeeding generation. In this case, individuals were computer-selected at random among those in the lowest class. The second selection procedure involved selection between and within maternal half-sib families. Progeny from each of the 36 - individuals in the preceeding generation were grown in replicated blocks for evaluation of response to inoculation with *Albugo*. Selection was then exercised between families to choose the six families with the lowest reaction upon inoculation. Half-sib family selection was conducted to minimize bias due to non-genetic variation. For traits with high heritability, mass selection would allow greater selection pressure and would be expected to achieve greater gains.

After three cycles of selection, all populations were increased as two samples of 100 individuals which were intermated within samples to produce seed for evaluation. Evaluation was conducted with inoculators and evaluators as factors in a randomized complete block design. Analysis of variance revealed that differences between inoculators and evaluators were non-significant. Mean values for populations are presented in Table 1.

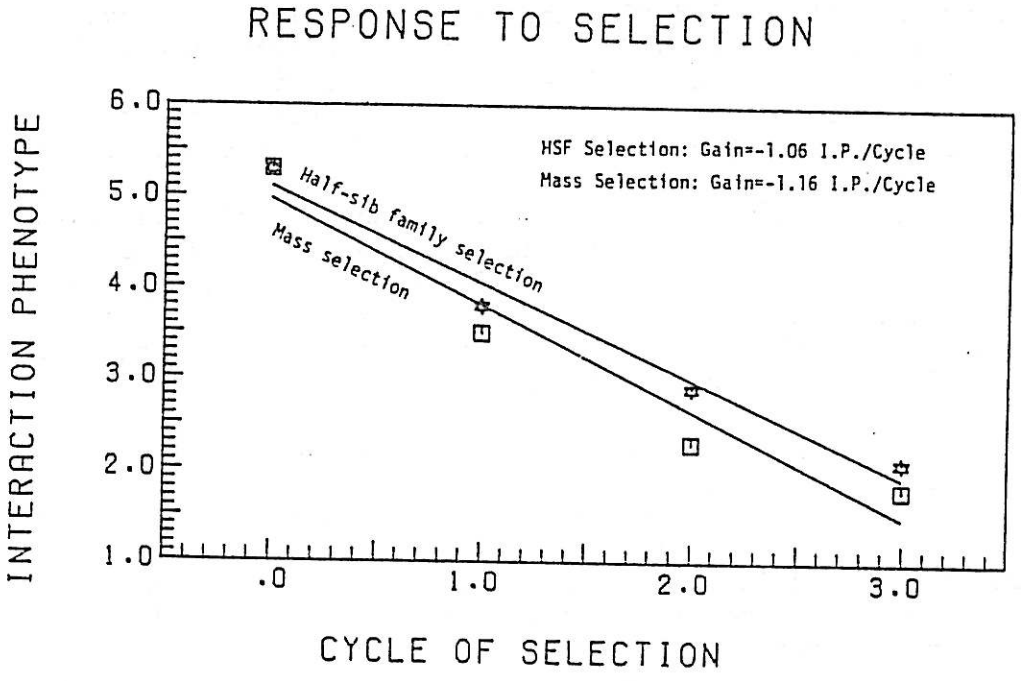
TABLE 1. POPULATION MEANS FOR INTERACTION PHENOTYPE (IP) OF *BRASSICA CAMPESTRIS*, CGS-1 AND *ALBUGO CANDIDA* RACE 2

POPULATION		MEANS	
Cycle	Method	IP	
Cycle 0		5.3	A
Cycle 1	Half-sib Sel.	3.8	B
Cycle 1	Mass Sel.	3.5	BC
Cycle 2	Half-sib Sel.	2.9	BCD
Cycle 2	Mass Sel.	2.3	CD
Cycle 3	Half-sib Sel.	2.1	D
Cycle 3	Mass Sel.	1.8	D

Mean separation based upon Duncan's Multiple Range Test, p = .05
IP: 1 = very low reaction type (high resistance); 5 = intermediate susceptibility; 9 = very highly susceptible

Duncan's Multiple Range Test for equivalence of mean values was conducted and is also presented in Table 1. Response to selection is presented graphically in Figure 1.

FIGURE 1.



Average gain per cycle of selection was estimated as 1.16 IP/cycle for mass selection and 1.06 IP/cycle for half-sib family selection, based upon a simple linear regression model. Deviations from regression were non-significant.

These data illustrate that variability for reaction to *A. candida* - race 2 among "susceptible" *campestris*, PHW-Aaa-1 individuals is due to quantitative genetic regulation. Furthermore, considerable gain in reisitance may be achieved quite rapidly via mass selection when starting with a susceptible base population.

VARIATION IN THE DEVELOPMENT OF *ERYSIPHE CRUCIFERARUM* Opiz ex L. Junell ON TWO CULTIVARS OF *BRASSICA NAPUS* L.

J.M. MUNRO and J.H. LENNARD

Studies were carried out on the development of two isolates of *Erysiphe cruciferarum* from *Brassica napus*, one collected from rape cv. Rape Kale (RK) and the other from swede cv. Magres (SM), on two cultivars of *B. napus*, a forage rape (cv. Barsica) and a swede (cv. Doon Major).

Leaf discs (1.8 cm diameter) were taken from the oldest green leaf of 11 week old plants and kept on benzimidazole (100 ppm) water agar. Discs were inoculated in a settling tower to ensure uniform deposition. Four replicates of each host/isolate combination were removed at intervals, and 50 spores examined on each replicate disc. To facilitate assessment, the stages of development of *E. cruciferarum* were considered in eight categories: ungerminated conidium, germinated conidium, appressorium (A), primary hypha (PH), secondary hypha (SH), expanding colony (EC), conidiophore initials (CI), and conidia.

The results showing the development of each isolate on each cultivar are given in Figure 1. Spores of both isolates germinated equally well on both hosts and the rates of germination in all combinations were similar. Appressorium formation began at 8 hours and was usually complete with all spores after 24 hours. Rates of germination and appressorium formation for both isolates were similar, suggesting no physiological difference in the inoculum. Moreover, the similar responses on both cultivars indicate no host interaction at these stages. Primary hyphae were seen at 24 hours with some spores, but there were fewer with RK on Barsica. At 48 hours secondary hyphae were found with SM on both cultivars and with RK on Doon Major, but RK did not show any secondary hyphae on Barsica until 96 hours. Only a very few spores of this isolate produced expanding colonies and none showed conidiophore development at 4 days. Expanding colonies were seen on the other three combinations at 72 hours and conidiophores were evident at 96 hours. However, conidiophore development at 96 hours was least with SM on Barsica (30%), intermediate with RK on Doon Major (80%) and 100% with SM on Doon Major.

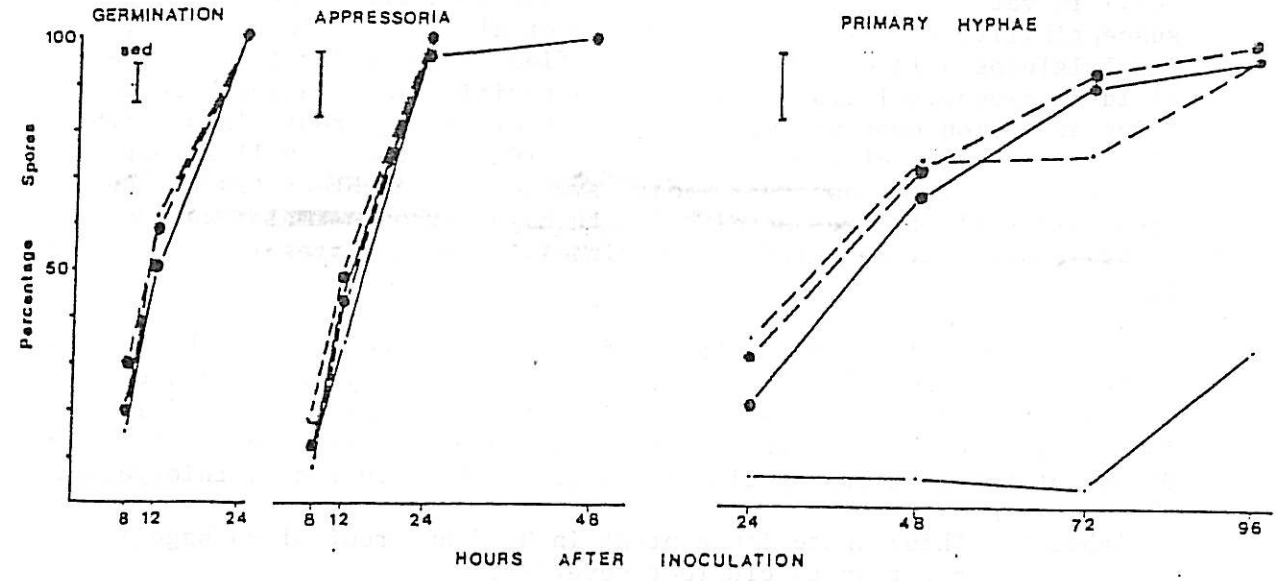
From Fig. 1b it can be seen that Doon Major shows a susceptible response to both isolates although RK showed slightly less development than SM at 96 hours. Barsica shows a higher resistance response to RK which failed to reach the conidiophore stage by 96 hours. The resistance response of Barsica to infection by RK is shown mainly by an inhibition at the appressorial stage. However, SM showed an intermediate response in that a proportion (30%) of spores had reached the sporulation phase at 96 hours, although the majority showing expanding colonies without conidiophores.

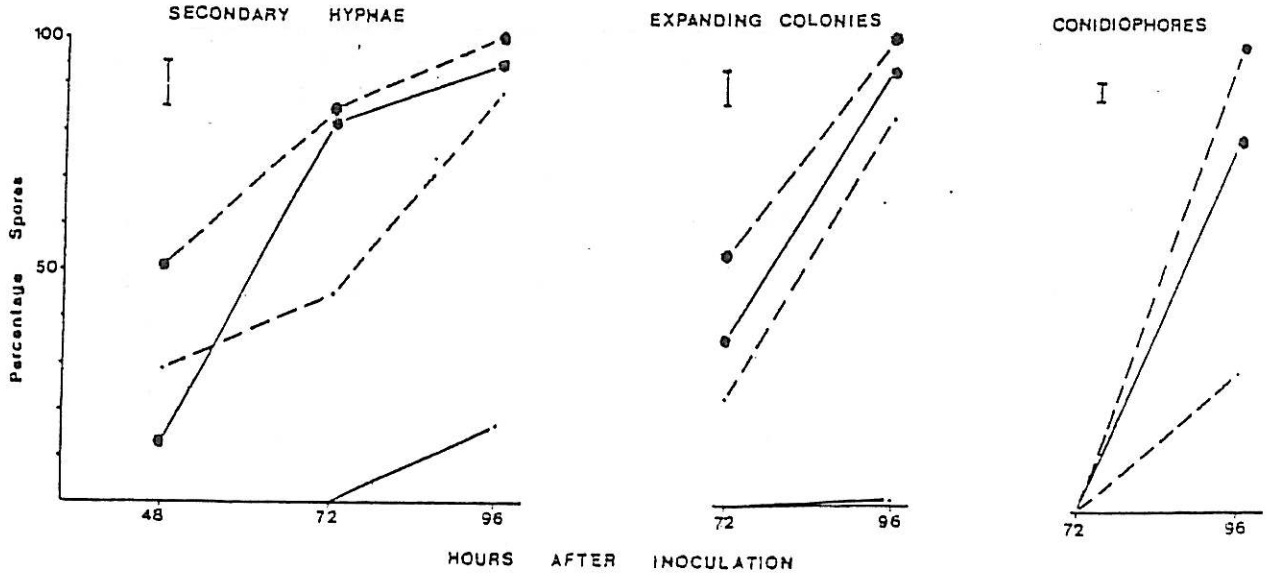
It would thus appear that there are at least two possible forms of resistance in *B. napus* to *E. cruciferarum* dependant upon the particular host/isolate combination. One is expressed early with a suppression of further development beyond the appressorium stage, while the second appears as reduced or delayed spore production. Further work is in progress with a wider range of isolates and hosts over a larger time span.

Figure 1. Development of 2 isolates of *E. cruciferarum* on 2 cultivars of *B. napus*.

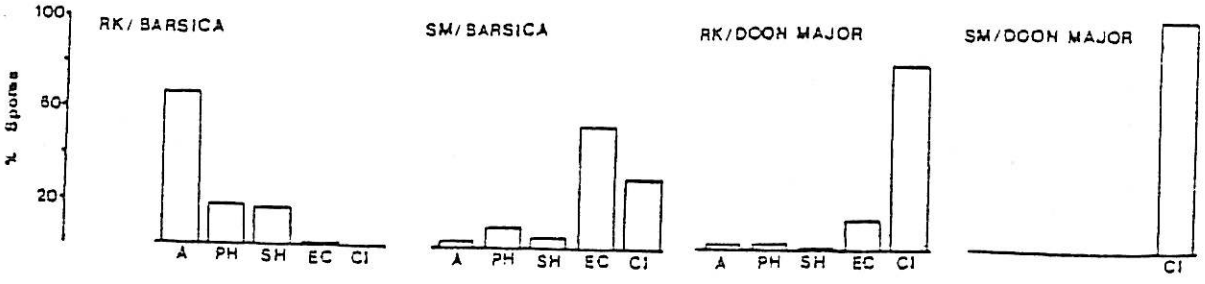
a) percentage of spores at different stages of development at different times after inoculation.

———— RK; - - - SM; · Barsica ; • Doon Major.





b) percentage of spores at different developmental categories 96 hours after inoculation.



RELATIONSHIP OF CLUBROOT DISEASE SEVERITY WITH INDOLYLGLUCOSINOLATE IN CABBAGES

Calvin Chong, M.S. Chiang and R. Crête

Previously we reported on the association of thiocyanate ion content in relation to the severity of clubroot disease (Plasmodiophora brassicae Wor.) in various cabbage lines segregating with different degrees of susceptibility to this pathogen (Chong et al. 1981). In cabbages, indolylglucosinolates have been identified as the major thiocyanate-yielding glucosinolates. Finding of a positive correlation between thiocyanate ion content and fresh weight of cabbage root tissue with different degrees of clubroot infection (Chong et al. 1981) supports the hypothesis that the abnormal growth symptoms of clubroot tissues in cruciferous plants are associated with higher than normal levels of auxins, which may be released from indolylglucosinolates (Butcher et al. 1976).

In September 1981, cabbage plants of line 81-21 and 81-34 with different degrees of clubroot infection were sampled and analyzed for contents of thiocyanate ion as previously described (Chong et al. 1981). Thiocyanate ion content increased with increasing clubroot severity in heads of line 81-34 but not in heads of line 81-21 (Table 1). In roots, thiocyanate ion

Table 1. Thiocyanate ion content in head and root of cabbage in relation to clubroot severity.

Line No.	Clubroot grade			
	0	1	2	3
		Head		
81-21	156±21[a]	101±7	106±10	151±6
31-34	124±3	137±27	147±16	219±27
		Root		
81-21	187±28	251±30	373±37	481±41
81-34	227±33	268±43	339±27	365±54

[a]Mean of 3 or 4 replications ±SE

content showed a consistent increase with increasing clubroot severity of both cabbage lines. This data confirm our previous findings (Chong et al. 1981).

In another investigation clubroot-infected (grade 3) and uninfected (grade 0) cabbage plants of line 81-35 grown on both loam and organic soils similarly were sampled and analysed for contents of thiocyanate ion. In comparison with tissues from uninfected cabbage, thiocyanate ion contents in head and root of infected cabbages grown on loam soil were higher by 69 and 30%, respectively, with corresponding increases of 326 and 375% for infected cabbages grown on organic soil (Table 2).

Table 2. Thiocyanate ion content in head and root of uninfected and clubroot-affected cabbages grown on two soil types.

Soil Type	Clubroot grade	
	0	3
	Head	
Loam	102±15[a]	172±24
Organic	134±12	571±58
	Root	
Loam	285±28	370±56
Organic	153±12	727±78

[a]Mean of 4 replications ±SE

Data for selected mineral constituents from samples of both soil types collected at harvest are shown in Table 3.

Table 3. Mineral contents in loam and organic soils.

Soil type	%					
	N	P	K	Ca	Mg	S
Loam	0.004	10.11	14.77	144.3	13.32	0.024
Organic	2.4	0.17	0.31	2.8	0.21	0.581

Previous evidence (Ju et al. 1981) suggested that higher levels of sulfur found in organic soil significantly influenced glucosinolate biosynthesis in roots of radish, turnips and rutabagas. The actual thiocyanate ion content in uninfected cabbages grown on organic soil were slightly higher in head or lower in root in comparison with corresponding samples from loam soil (Table 2). Notwithstanding the wide variation in contents of mineral constituents between soil types (Table 3), the markedly higher increase of thiocyanate ion in both head and root of infected cabbages grown on organic soil may indicate a relationship with the elevated contents of sulfur in organic soil (Ju et al. 1981), possibly associated with increased assimilation of sulfur-containing amino acids which are glucosinolate precursors. Further studies are required to elucidate this hypothesis.

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STORAGE OF PLASMODIOPHORA BRASSICAE (WOR.)

Christopher B. Miller

A factorial experiment was conducted to determine the more optimum conditions for storing resting spores of Plasmodiophora brassicae (Wor.). Four soil types, three temperatures and three retrieval dates were studied.

Ten milliliters of fresh inoculum prepared by standard methods (1) was added to 100 milliliters of soil media and heat sealed into a 10x14 cm aluminum foil seed packet. The inoculum consisted of an isolate mixture, E.C.D. 31/31/31, at approximately $100x10^9$ spores per milliliter.

The experimental treatments were as follows:

I. Soil Type
   1. Jiffy Plus commercial soil mix pH 6.1
   2. Canadian sphagnum peat moss pH 3.5
   3. Yolo silty clay field soil pH 7.5
   4. Screened river sand pH 7.3

II. Temperature
   1. -10 to -15°C (freezer)
   2. 3 to 5° C (refrigerator)
   3. 18 to 26° C (office drawer)

III. Retrieval Date
   1. Three months
   2. Six months
   3. Twelve months

After storage the moist soil-spore mixture was placed in an indentation

in the surface of a 10 centimeter peat pot filled with Jiffy Plus soil mix. Seeds of Michihili Chinese cabbage were sown directly into the mixture and covered with approximately one centimeter of vermiculite. The plants were grown in the greenhouse under 24 hour flourescent lights with a mean ambient temperature of approximately 24°C. After six to seven weeks the treatments were assessed for clubroot severity and scored on a one to nine scale. Each treatment was then given a disease index score according to Rene Crete's method (2).

The results after one year are shown in Table 1. Retrieval of viable spores was significantly repressed by the coldest temperature. The best results were obtained with refrigerator storage, but retrieval can be expected when the packets are stored at room temperature.

Table 2 illustrates the comparative efficiencies of the individual factors. When the freezer treatment is excluded there is no significant difference between storage for the six month or 12 month retrieval date indexes.

There is a significant interaction between soil type and temperature and also between soil type and retrieval date.

Many clubroot workers have traditionally, and often successfully, stored frozen galls for extended periods of time. However, it was the requirement for large areas of freezer space and the occasional loss of isolates that prompted this study. With the resting spore method described here it should be possible to store more isolates under less restricting conditions.

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2. Crete, R. 1975. Clubroot Newsletter 4:8.

TABLE 1

TEMPERATURE	SOIL TYPE	INDEX
-10 to 15°C	Jiffy	22.3 d(2)
	Peat	11.1 (1)d
	Field Soil	17.0 d
	Sand	11.1 d
3° to 5°C	Jiffy	96.2 a
	Peat	86.7 a
	Field Soil	23.8 d
	Sand	51.5 bc
18° to 26°C	Jiffy	47.0 c
	Peat	73.9 ab
	Field Soil	16.5 d
	Sand	12.3 d

(1) With a 1-9 rating scale, the equivalent of zero infection converts to 11.1 with the index.

(2) Values followed by the same letter are not significantly different at the 5% level based on A.N.O.V.A., L.S.D.

TABLE 2

FACTOR	TREATMENT	INDEX
Soil Type	Jiffy	54.0 a(1)
	Peat	58.2 a
	Field Soil	31.5 b
	Sand	53.0 a
Temperature	-12°C	28.0 C
	3-5°C	68.8 a
	18-22°C	50.7 b
Retrieval Date	3 months	55.4 a
	6 months	53.0 a
	12 months	39.1 b

(1) Within factor values followed by the same letter are not significantly different at the 5% level based on A.N.O.V.A., L.S.D.

ORABANCHE RAMOSA L., A NEW RAPESEED PARASITE IN SOUTHERN SPAIN

E. Sobrina Vesperinas

The genus Orabanche is entirely made up of species that are necessarily parasites because they lack chlorophyll. In many Mediterranean countries, its presence represents a serious problem for a large number of crops.

In the 1980/81 agricultural season, rapeseed plants in some isolation fields in the province of Sevilla were detected for the first time in Spain to be acutely affected by an Orabanche parasite, which has been defined as O. ramosa L. following WEBB (1964). This is a very variable species in morphological terms, capable of infecting a wide variety of hosts. It has been cited on Cannabaceae (Cannabis sativa L.) Solanaceae (Solanum spp., Lycopersicum sculentum Miller, Labiatae (Rosmarinus officinalis L., Lamium spp.), Compositae (Senecio spp., Taraxacum spp., Chrysanthemum segetum L.), Geraniaceae (Geranium spp.), Cruciferae (Crambe maritima L.), Diplotaxis spp. and Umbelliferae (Daucus carota L., Eryngium campestre L.).

Attacks can drastically affect yield. A field in Guillena (Sevilla), where 100% of the plants were infested, showed a yield of 50% in relation to non-infested controls.

Spread of the parasite in Spain, including the subsp. ramosa, subsp. mutelli (F.W.Schultz) Coutinho and subsp. nana (Reuter) Coutinho, based on data obtained from the herbarium of the Real Jardin Botanico of Madrid, are shown in Fig. 1.

The parasite is distributed over a wide area, and although its evolution with respect to rapeseed is difficult to foresee, it is beyond any doubt that it constitutes a serious potential threat for that crop in Western Andalucia and perhaps throughout Spain.

Measures have been taken to restrict the growth of the parasite by severe controls in seed production fields and by advising farmers not to repeat the crop on infected fields.

A search for resistance through the screening of a large number of varieties and breeding lines has been started as well as selection of presumably resistant plants in infected fields.

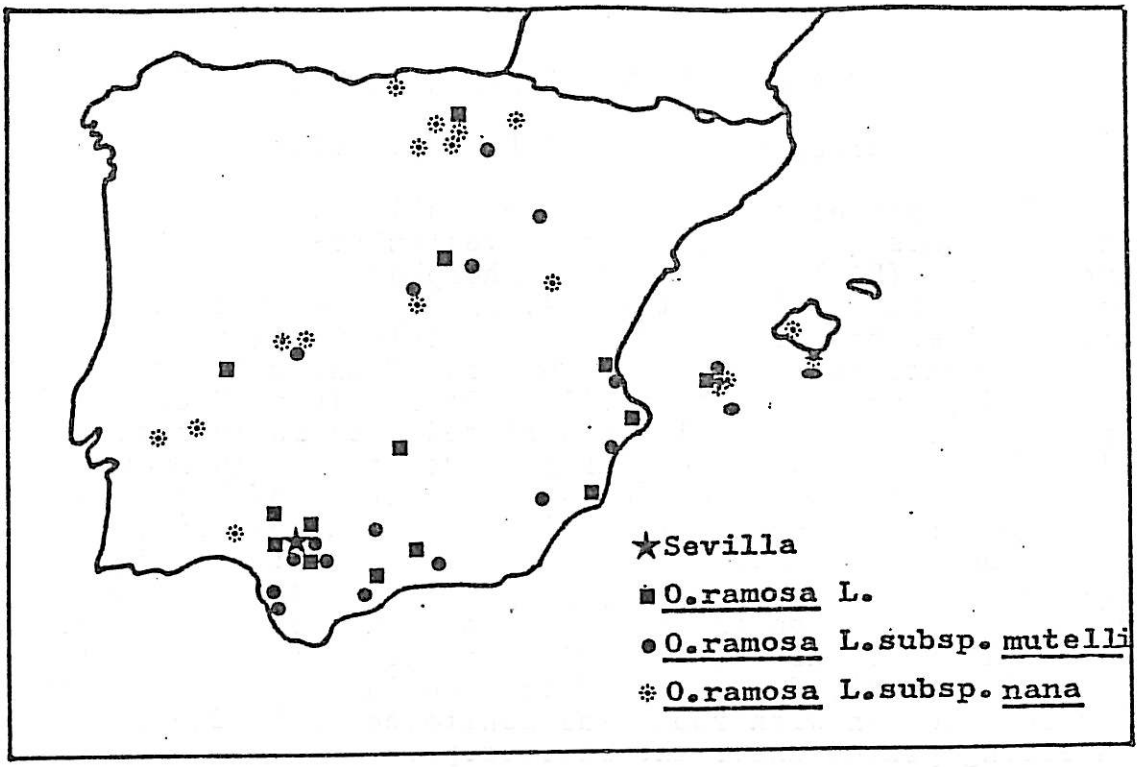

Fig. 1 - Distribution of Orobanche ramosa L. in the Spanish Peninsula and Balearic Isles. (Herbarium at the Real Jardin Botánico of Madrid).

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WHAT BLOCKS VA MYCORRHIZAE IN BRASSICA?

Marian G. Glenn and Paul H. Williams

The cruciferae are among the small group of plant families whose roots do not form vesicular-arbuscular mycorrhizae (VAM). VAM improve phosphate absorption, especially in P-deficient soils, and species without VAM are confined to early successional, colonizing roles, or to P-adequate soils. The production of unusual secondary compounds, such as mustard oils (MO; prominent S-compounds in all cruciferae) is also associated with early successionals. This study was undertaken to determine how MO might be linked with the block to VAM. Cultivars of Brassica napus and B. campestris (Canadian Rapeseed, or Canola) bred for a range of MO levels, and spores of VAM fungi Glomus mosseae and Gigaspora gigantea were germinated together on low-P mineral salts agar in 15 cm plastic petri plates. MO levels were further controlled by growing some plants as well as excised roots in S-free media. Germ tube growth and interaction with roots was monitored at 70-200 x by inverting plates under the microscope.

Germ tube growth around brassica roots was compared to that around compatible hosts tobacco and tomato. Compatible roots elicited hyphal branching and developed normal mycorrhizae on agar, but brassica roots elicited fewer, shorter hyphal branches, which occurred only close to the root surface, regardless of MO level. Normal hyphal branching occurred near brassica if a host root was also present, but brassica roots were not penetrated. These data suggest that host rhizosphere provides a growth stimulus lacking in brassica, but fungal growth stops at the brassica root surface. Growth may be inhibited because the host-supplied stimulus will not diffuse beyond the brassica root surface, or there may be an active block to penetration other than MO. Since VAM penetrate nearly all plants, the data suggest that brassica rhizosphere physiology differs from most other plants in some basic way other than production of MO. The stimuli leading to successful development of VAM are not known, however, compatible hosts block VAM penetration when given adequate phosphate, probably due to a change in root exudates. Study of the mechanisms controlling this block to VAM in compatible roots may lead to new insights concerning the roots of brassica, as well as the signals leading to successful VAM penetration.

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Key to professional interests

Genera and species

1. *Brassica oleracea*
2. *Brassica campestris* (rapa)
3. *Brassica napus*
4. *Brassica* other species
5. Other genera
6. Interspecific & inter-generic hybrids

Usage

a. Vegetables and condiments
b. Fodder
c. Green manure
d. Oil and protein

Pests, diseases and weeds

e. Animal
f. Weeds
g. Fungal
h. Bacterial
i. Viral
j. Mineral

Disciplines

k. Agronomy
l. Pathology
m. Physiology
n. Taxonomy and Evolution (including resources and gene banks)
o. Genetics and cytology
p. Breeding
q. Mating systems
r. Nutrition and chemical composition
s. *In vitro* culture
t. Variety testing (including National Lists and Breeders rights)
u. Seeds, production and performance

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