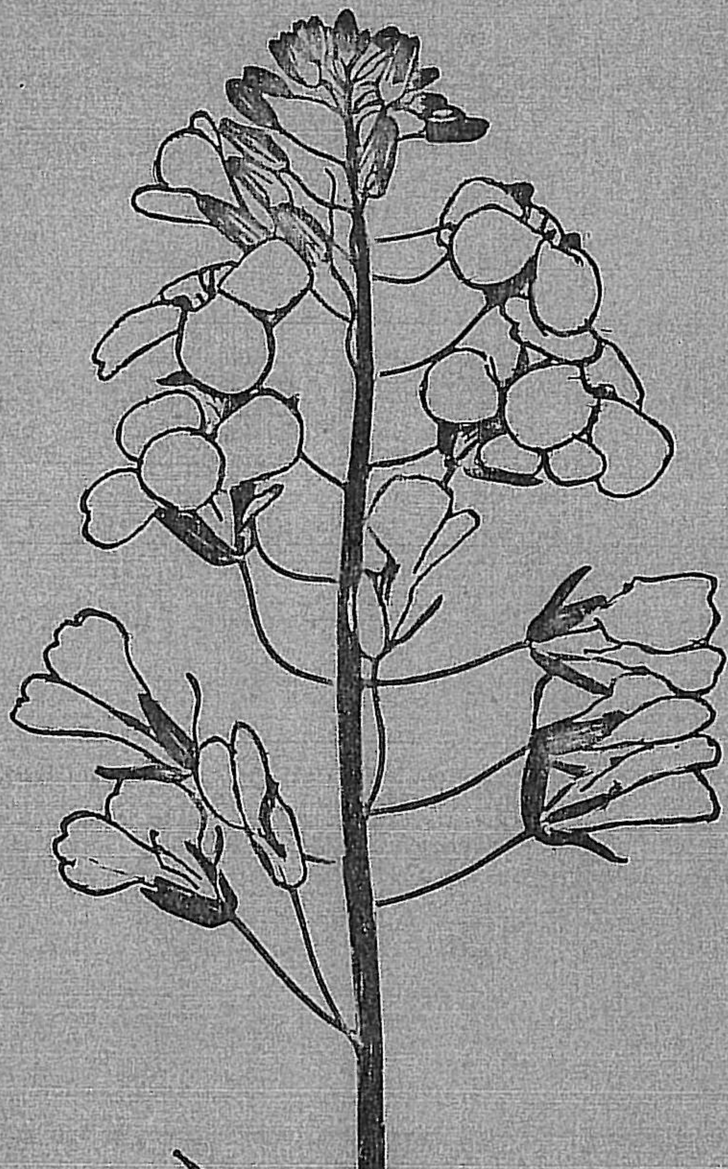
EUCARPIA
CRUCIFERAE



NEWSLETTER No 1
November 1976

EDITORIAL

At a meeting of the Vegetable Crops Section of Eucarpia held at the Scottish Horticultural Research Institute, Dundee, U.K. on 25th-27th September 1974 it was suggested that there was a need for a newsletter concerned with the breeding of Brassica crops. We were asked to investigate this and to produce the first edition if there was sufficient interest. This we have now done although the scope has been changed to include other cruciferous crops. The purpose of this Cruciferae Newsletter is to provide breeders with up-to-date information of work in progress and results obtained prior to formal publication. It is intended that it should be circulated internationally to obtain the widest benefits. Its success will depend on the support that you, its readers, are prepared to give, especially through the contributions you make to it.

This edition has been financed largely by means of a grant by the Board of Eucarpia. If similar support is not available for the next issue it will be necessary to make a charge which at present prices is likely to be about £0.80 per copy plus postage. Since the administrative costs (particularly in staff time) of collecting these sums may be considerable an alternative source of funds is being sought. Suggestions would be welcomed by the editors.

At the back of this edition there is a form on which you can give the editors some guidance to help them produce a newsletter which will truly serve international research with crucifers. Please complete and return it as soon as you have read this copy, while the ideas are still fresh in your mind. We would like to know if a spring or autumn issue (northern hemisphere nomenclature) is preferred. Do you have suggestions for subjects, reviews or particular authors for the next issue? Do you wish to propose additions to the mailing list? Is your name and address correctly given?

Readers should note that this newsletter does not constitute a formal publication. Contributions may be speculative or still needing confirmation. Only thus can the newsletter be really up-to-date. Results should not be quoted (except in the newsletter itself) without the author's permission.

We hope that this Cruciferae Newsletter will reach readers in every country where brassicas and other crucifers are the subject of scientific research.

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List of CONTENTS is on the inside of the back page

Forthcoming Meetings.

1. A meeting, organised by Scottish Agricultural Development Council and Scottish Plant Breeding Station, will take place at Pentlandfield, Edinburgh on 10th and 11th February 1976. Papers will be presented covering the following main topics concerning forage brassicas in U.K.:

   1) Plant Breeding/Disease Resistance.

   2) Pathology.

   3) Agronomy/Crop Husbandry.

   4) Variety Testing.

   5) Animal Nutrition.

   6) Utilization and Systems.

   The above meeting will be preceded, on 9th February, by an informal meeting of specialists in U.K. involved with Plasmodiophora brassicae; physiological studies, life cycle, population survey work, chemical control etc.

   For more precise details of the above meetings please contact Mr I.C. Beattie, Scottish Agricultural Development Council, Bush Estate, Penicuik, Midlothian, EH26 OPZ. Tel: 031 445 3461.

2. An international conference on Plasmodiophora brassicae will be held on 5th - 9th September, 1977, at the University of Wisconsin - Madison, Wisconsin, U.S.A. The conference has been established on the centennial of the publication of the classical work of M.S. Woronin who first identified P. brassicae as the causal agent of club-root disease.

   Details are available from Professor P.H. Williams, Department of Plant Pathology, 1630 Linden Drive, University of Wisconsin - Madison, Wisconsin 53706, U.S.A.

BREEDING RESEARCH ON COLE CROPS AT THE IVT.

N.P.A. van MARREWIJK
Institute for Horticultural Plant Breeding (IVT), Wageningen, The Netherlands

At our Institute (IVT) research on cole crops is done in several departments, e.g. Cole Crops, Biochemistry and Embryology.
Breeding research itself is carried out by the Cole Crops department (N.P.A. van Marrewijk and D.L. Visser). The most important fields of research are:

1) Incompatibility research related to the production of hybrid varieties of Brussels sprouts, cabbage and kohlrabi. Special attention was paid to identification and dominance relationships of S-alleles. As a result a collection of about 20 different S-alleles in Brussels sprouts has been supplied to interested commercial breeders in the Netherlands. A publication on dominance relationships is being prepared in cooperation with Mr. J.G. van Hal (formerly Unilever, Duiven). In the last 3 years much time has been devoted to investigations on the influences of temperature, relative humidity and genetic background on the activity of S-alleles. We found a decrease in self-incompatibility with alternating day and night temperatures of 23/14 or 26/14°C, especially for the weaker S-alleles. Results of relative humidity experiments are being analysed and will be published.
2) Kohlrabi breeding for early glasshouse cropping. Special aims were uniform corm ripening for once-over harvesting and earliness. Therefore the possibilities of hybrid varieties are studied. A number of promising inbred lines have been released to commercial breeders. For selection under normal growth conditions and for shortening the breeding cycle vernalization experiments were carried out and GA_3 was applied to promote bolting (See: Sci. Hort. 4(1976), 367-375).
3) Resistance breeding in white storage cabbage against grey speck disease, a physiological disorder appearing during storage. This research finished last year with a study of the genetics determining the susceptibility to this disorder. Previously a number of insusceptible pedigrees and inbred lines were released to the commercial breeders.
4) Conservation of old Brussels sprouts varieties and strains. Because of the increasing importance of Brussels sprouts hybrids the old open pollinated varieties get lost. This might jeopardize future hybrid breeding as the original gene pools are no longer available and the hybrid varieties are no good sources owing to genetic erosion during inbreeding. About 160 varieties and strains from Dutch, German, Swiss, French or English origin have been propagated and are placed in long term storage.

In the Biochemistry department (H. Roggen and A.J. van Dijk) research is done on the incompatibility barrier itself and on breaking this barrier by chemical or physical methods. Stigma and pollen behaviour were studied by Scanning Electron Microscopy, resulting in Roggen's theory of an inhibiting wax layer on th^ stigmatic surface. Proceeding on this basis he started research on a number of physical pollination techniques, namely: Electric aided pollination (EAP), Steel brush pollination and Thermically aided pollination (TAP). Most chemical treatments hardly influenced incompatibility. In 1975, however, the Rape-seed Pollen Coat technique gave promising results. Especially with the EAP, TAP and RPC techniques the self-seed production could in many cases compete with bud pollination.

In the Embryology department Braak and Franken did many experiments on anther culture in *Brassica oleracea* L. After 2 years of experimenting they had not succeeded in obtaining haploids from these cultures. The work has been terminated.

Eenink carried out extensive investigations on matromorphs in *Brassica oleracea* L. This eventually resulted in his Ph.D. thesis. He could prove that matromorphs did not result from doubled haploid cells after prickle pollination (See: Euphytica 23(1974), pp. 429, 435, 711, 719, 725 and 24(1975) pp. 33, 45).

BRASSICA RESEARCH AT MICHIGAN AGRICULTURAL EXPERIMENT STATION

S. Honma, Dept. of Horticulture, Michigan State University, E. Lansing

Clubroot tolerance in cauliflower

Breeding for tolerance to this disease is being carried on in a limited way. Dr. Paul Williams, Wisconsin Agricultural Experiment Station provided pollen from his tolerant material for hybridization a few years ago. Lines resulting from this cross is being tested for tolerance to the disease. Criteria used in the selection is based on tolerance of the plant to produce a crop in an infested field. Our test plot is infested with races 1 and 3, which was collected from clubs in grower's fields. The progress of this work is very slow.

Black rot tolerance in cauliflower and broccoli

Several years ago cauliflower was hybridized with cabbage (Early Fuji) to obtain lines that showed high degree of tolerance to black rot. These selections were selfed and tested. The F_3 lines were backcrossed and intercrossed. Presently, selection for curd quality and tolerance is being made. One of the F_2 selections from the above cross was crossed with broccoli (MSU 108 tolerant to club root) and selection for head quality and tolerance was made. Since the head quality is poor this material will be backcrossed to broccoli.

Early maturing cauliflower.

In Michigan, there is a need for cultivars to extend the marketing season. Fall varieties grown for harvest prior to September 15 do poorly due to high temperatures (80-90^{o}F). To extend the season 30 days, cultivars maturing during warm weather of summer became necessary. Crosses between Snowball types and Patna types were made to obtain lines that would produce high quality curds when they matured during warm weather. It was also necessary since most of the cauliflower are not blanched to select plants with upright leaves to protect the curd from direct sunshine. During the process of selection plants showing slight yellowing of the curds when exposed to direct sunshine were noted and duly selected. Since one of the parents was of the Patna type, it was necessary to place emphasis on head density. A limited commercial trial has been made with some of the selections this past season.

RESEARCH ON BRASSICA AND RAPHANUS AT THE UNIVERSITY OF WISCONSIN

Paul H. Williams

Our program on crucifers at Madison is directed primarily toward the development of multiple disease resistant lines of Brassica oleracea and Raphanus sativus suitable for release to the United States and world seed industries. Much of our efforts on pathology are directed toward the development of effective multiple disease resistance screening methods in which large populations of plants can be simultaneously or sequentially screened for resistance to as many as six or eight diseases. As new screening methodologies are developed, they are used in evaluating potentially useful forms of resistance in our collection of Brassica and Raphanus accessions. Pathogens with which we are routinely working are turnip mosaic virus, cauliflower mosaic virus, Xanthomonas campestris, Plasmodiophora brassicae, Peronospora parasitica, Aphanomyces raphani, Albugo candida, Erysiphe polygoni, Leptosphaera maculans (Phoma lingam), Fusarium oxysporum f. sp. conglutinans, Rhizoctonia solani. We are also selecting for absence of the non-parasitic disorders tip-burn and black speck.

Underpinning our breeding work is a genetic program directed at broadening the base of disease and insect resistance found in B. oleracea through interspecific and intergeneric gene transfer. In initiating this genetic study, A. candida, P. parasitica and P. brassicae have been selected for experimental transfer of resistance to B. oleracea from related species.

A major criterion in facilitating our studies on the inheritance of resistance has been the selection of rapidly cycling lines. Heavy selection pressure is placed upon each of the species in order to develop working lines which have short flowering and seed maturation times, no seed dormancy and a high potential for both self and cross compatibility. Our best progress to date has come with B. campestris where we have developed lines in which we can cycle the plants every 45-50 days. By crossing B. alboglabra with B. oleracea, we have been able to shorten the reproductive cycle of B. oleracea to 75-90 days. Rapid flowering types have also been selected in B. nigra, B. carinata, B. juncea and B. napus.

Along with studies on the inheritance of genes for disease resistance, we are also examining the linkage relationship of resistance genes with various other marker genes in each species. Although in the initial stages of this study we are dealing with genes conferring race-specific resistance to various pathogens, our long-term objective is to identify sources of non-specific disease resistance in Brassica and to develop the genetic and breeding system appropriate for their transfer and maintenance in populations of brassicas.

A third component of our research program concerns the development and expansion of new uses for Brassica and Raphanus in the United States agricultural economy. An evaluation of the potential of brassicas as oil seeds, forages and fodders is underway in Wisconsin and is planned for different growing regions of the United States. Cooperative research with USDA chemists involves the analysis of glucosinolates in the major Brassica and Raphanus cultivars grown in the United States. As part of this collaboration, the heritability of glucosinolates in B. oleracea is being studied.

BRASSICA BREEDING AT THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

C. North

Historical. Since Brassica breeding was started at SHRI in a small way in 1955, the following aspects have been studied; genetic male sterility discovered at Invergowrie 1957 (6th Annual Report SHRI 1959; 9th Annual Report 1962); use of the selective gametocide FN450 to induce male sterility (8th Annual Report 1961); inheritance of B. sprout to susceptibility to internal browning (Priestley & North 1962); glossy mutants in B.sprout (North & Priestley 1962); induction of matromorphs by pollination of B. sprout with *B. campestris* (18th Annual Report 1972); serological technique for identification of S-allele status (Sedgley 1974); partial self compatibility (Hodgkin 1975).

Varieties released. Two F_1 varieties have been released; the B. sprout "Gleneagles" in 1970 and cabbage "Celtic Cross" in 1971. Gleneagles gave high yields of good quality sprouts but the stems were short and picking was difficult. Attempts to reselect for longer stems was unsuccessful and the variety has now been discontinued. There were some problems with seed production of Celtic Cross but these have been largely overcome and it is an important variety for autumn and winter harvesting. Work is still in progress (A.J. Redfern) using the parent lines of Celtic Cross to produce similar varieties with different periods of maturity. However the present policy is to work on problems associated with the breeding of Brassicas rather than to produce new varieties.

Current work. This centres round (1) the early identification of sibs in F_1 varieties, (2) inheritance and cytogenetic studies, (3) the breeding of calabrese (See paper by Redfern in this Newsletter), (4) inherited differences in seed germination and emergence (See Ibrahim).

(1) Work with glossy foliage mutants to identify seedling sibs continues. Materials have been released to seed firms and improved recessive glossy parent lines (4 different loci) are being developed utilising a cyclic single cross technique and employing selection indices (Hodgkin & Redfern). A technique for identification of sibs in seeds and seedlings by electrophoretic techniques has been considerably refined and is the subject of a paper in the Newsletter (Wills & Wiseman).

(2) A study in depth of linkage groups in *Brassica oleracea* is being carried out by A.B. Wills. Recently T. Hodgkin has started a study on yield components of B. sprout and their heritability.

References

Hodgkin, T. (1975). Studies on the inheritance of pseudo-compatibility in *Brassica oleracea*. Ph.D. Thesis Dundee University.

Priestley, Greta & North, C. (1962). Inheritance of susceptibility to internal browning of brussels sprout. *Nature, Lond* 193, 801.

North, C. & Priestley, G. (1962). A glossy-leaved mutant of brussels sprout. *Hort. Res.* 1, 95-99.

Sedgley, Margaret (1974). Studies on S-allele incompatibility in *Brassica oleracea*. Ph.D. Thesis St. Andrews University.

FORAGE CROPS OF BRASSICA IN NORWAY. RESULTS FROM BREEDING PROGRAMMES.

H.C. Svads.

The following species of Brassica for forage production are grown in Norway:

Br. campestris L. ssp. rapifera, Turnip, Green Fodder Turnip	5000 hectare	
Br. napus L. ssp. rapifera, Swede,		
Br. napus L. ssp. oleifera, Fodder rape,	6000	"
Br. oleracea L. ssp. aceaphala, Marrow Stem kale,	2000	"

Of the root type swede is most grown and cover approx. 2/3 of the 5000 hectare area. Both turnip and swede are grown for winter feeding while fodder rape, marrow stem kale, green fodder turnip and leaves from turnip and swede are used for grazing, silage or feeding as fresh fodder. Roots of swede are also used as vegetable.

At presant most of the breeding work is carried out at the Farm Crops Institute, Agricultural University of Norway. A few seeds companies and farmers are, however, carrying out their private breeding. Their type of breeding programme can be characterised as mass selection in an already existing variety. This can be varieties selected for a particular district, for a particular purpose, resistant against diseases and pests etc.

The targets of our breeding programme can be summarized as follow:
1. Good yield of dry matter.
2. High dry matter per centage.
3. Resistance against pests and diseases.
4. Suitable for mechanical harvesting.
5. Good keeping quality.
6. Swede: Good quality for human consumption.

The breeding programme is based on the following procedure:
1. Selection of parent individuals.
   Parent individuals are usually selected on the basis of morphological evalution, genetical variation and analysis of their dry matter content.
2. Controlled pollination with emasculation and hand pollination.
3. F_1- generation in observation plots.
4. Seed production arranged both in polycross and sib-crossing on the basis of F_1 selected families.
5. Progeny test and selection of suitable families by using seed from polycross.
6. Strain formulation on basis of selected families by using seed from sibcrossing.

Important results from the breeding programme. The presented results are produced from the latly completed State trials carried out in Norway.

Turnip.									
Foll (Norway)	8.7	tonnes	DM	per	hectare,	1.0 %	club	root.
Mean 4 Danish varieties	7.9	"	"	"	"	4.8 %	"	"
Kvit mainepe (Norway)	7.8	"	"	"	"	0.5 %	"	"
Swede.								
Bangh. Gokstad (Norway)	9.9	tonnes	DM	per	hectare,	10.1 %	club	root.
Bangh. Olsgård (Norway)	9.8	"	"	"	"	8.2 %	"	"
Mean 5 Danish varieties	9.8	"	"	"	"	9.7 %	"	"
Wilh. Øtofte (Denmark)	9.8	"	"	"	"	6.3 %	"	"
Gry (Norway)	9.5	"	"	"	"	2.1 %	"	"

Club root, Plasmodiophora brassica W. is a common and serious disease on Brassica plants in Norway. Among varieties and between species is à considerable variation in resistance against club root. The variation can be used in a breeding programme to make better resistant varieties. The variety Gry is the result of such a work. The turnip variety Foll has some resistance against club root, but we are trying to make it better. Testing of club root resistant materials is carried out in fields particularly infected with Plasmodiophora brassica.

Until quite recently our breeding programme has been based on crossings between varieties belonging to the same species or sub-species. To be able to continue the progress we have made in the past we beleive it is necessary to include other species and sub-species of Brassica and perhaps other genus of the Crusiferae family. Quite recently the breeding programme has been changed to these ideas. At the moment much of the materials are at an early stage of developement.

CRUCIFER IMPROVEMENT COOPERATIVE

Paul H. Williams

The Crucifer Improvement Cooperative (CIC) is an organization of individuals representing broad aspects of basic and applied research on crucifer improvement and production. Though the current membership consists largely of Americans, the organization is intended to be international in scope, and representatives from institutions in Canada, Denmark, England, Holland, Japan, Peru, Republic of South Africa, Scotland and Venezuela are on the current membership roster. Members are largely from state and federal institutions, from private seed production and sales organizations, crucifer processors and shippers, and crucifer growers. Disciplines represented are breeding, genetics, pathology, entomology, horticulture, chemistry, nutrition and many others.

The CIC was formed in 1962 with the objective of providing an informal forum through which those interested in crucifers, in the broadest sense, might meet to report on research and to exchange ideas on crucifer improvement. No publications are prepared. The CIC normally meets every two years, usually in an area where crucifers are being grown or where some aspect of crucifer production or research is emphasized. At each meeting, the next meeting place and dates are selected. The host serves to organize the program and provide field plot evaluations when appropriate. Meetings are attended by 30-50 members and usually consist of one and a half days of discussion sessions followed by a half day or more of field plot, crop production or research visitation. Past meetings have been held at Ithaca, NY; Madison, WI; Charleston, SC; Mt. Vernon, WA; Sanford, FL; and Geneva, NY. Meetings in 1976 were at El Centro, CA in January. The next meeting of the CIC will be held at Weslaco, TX in February 1978. Dr. Thomas Lonbrake, Department of Horticulture, Texas A&M University, College Station, TX 77843 will host the 1978 meetings.

Membership in the CIC is open to all having an active interest in crucifer improvement and wishing to be on the membership mailing list. Currently, there are about 150 names on the membership roster. Those interested in being on the membership roster should notify Paul H. Williams, Department of Plant Pathology, 1630 Linden Drive, University of Wisconsin, Madison, WI 53706.

A SEED BANK of WILD CRUCIFERS

C. GOMEZ-CAMPO

Beyond any doubt, the main centers of diversity for the tribe brassiceae are located in the S.W. Mediterranean region, mostly in Morocco, Spain and Algeria. Out of 54 genera, 45 are either exclusive of this region or clearly present a maximum of variability within it. At species and sub-species level, such pattern of distribution still becomes more accentuated. Though centers for other tribes are located in other parts of the world, it can be said that, in general, crucifers are very well represented in the W. Mediterranean region.

With that fact in mind and with the working idea of improving the present procedures of seed collection and storage as used by botanic gardens and related institutions, the elaboration of a bank of crucifer seeds was started by 1965. Main lines of action consisted of 1) the use of long term preservation methods for a maximum longevity, 2) minimization of botanic misidentifications, and 3) coverage of the widest range of variability within the family. While the last two points are a logical consequence of specialization into a single botanical group, the use of seed preservation methods was expected to avoid extra work consumed in future re-collections and/or periodic multiplications which are in turn a source of undesirable crosses, misidentifications and reduction in genetic variability.

Some 2-4 weeks per year have been expended in many field trips through Spain, Morocco and Algeria, plus one trip to Iran. Most samples were therefore collected directly from their own natural habitats. A number of them was obtained from botanic gardens and included in the collection after multiplication and checking of its identity. Multiplication in the garden or greenhouse was carried out in those cases where it was difficult to collect the right amount of seeds in the wild. After cleaning, samples were stored for a few weeks in a plastic hermetic chamber with calcium chloride or silica-gel for pre-desiccation. This was found to have a favorable effect on germination, since many crucifer species may present some slight post-harvest dormancy.

Conservation methods as used in this collection involve the simultaneous use of low humidity, low temperature and low oxygen within individual sealed glass containers. Though one or two factors may be sufficient to extend seed viability over a long period, a combination of three was used as a safety redundant measure. The use of individual containers guards against changes in storage conditions every time a sub-sample is removed. Humidity was lowered by enclosing a small amount of silica-gel in each capsule. Air was substituted by carbon dioxide before sealing. Storage is done in a cold room at -5°C.

Stored taxa neared 500 by October 1976, including some 130 general. Due to the geographical reasons commented above, approximately 40% of this material belongs to the tribe brassiceae, including many wild Brassica species and subspecies. A catalogue is published periodically and sent to a number of scientists involved or simply interested in basic or applied crucifer research.

GOMEZ-CAMPO, C. (1969). "The availability of crucifer seed from European botanic gardens" FAO Plant Introduction Newsletter 22: 25-32.

---------------------- "Preservation of West Mediterranean members of the cruciferous tribe brassiceae" Biological Conservation 4: 355-360.

---------------------- "A germ plasm collection of crucifers" Catalogos Instituto Nacional de Investigaciones Agrarias (Madrid) 1: 1-35

Gene-bank of Cruciferous crops

The people concerned with any aspect of the breeding of Cruciferous crops ought to get organised to get a gene-bank going. The variety of crops is big and each crop has its own, in cases almost overwhelming, variability. It would have to be a big institution to take care of this treasure, but there are no "mega crops" (like the small grains, or the potato) to carry the financial burden. We can only do it by subdividing this voluminous subject and share out the responsibilities amongst the parties involved, as far as possible. Anyone interested should contact me: Hille Toxopeus, S.V.P., P.O. Box 117, Wageningen.

BREEDING CALABRESE AT THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

A.J. Redfern and A.B. Wills

Calabrese develops well in the normally cool summer climate of Scotland, where it is a relatively new crop for processing. There is potential for a greatly expanded acreage, both in Scotland and the rest of Britain, particularly if varieties more suitable for machine harvesting were available. A project was begun therefore at this Institute in 1975 to breed adapted material particularly suitable for mechanical harvesting.

Morphological criteria for suitability for harvesting by an experimental harvester were established and selections made from non-hybrid cultivars grown in trial in 1975 and 1976. Populations have been derived from these selections for immediate isolation and characterisation of S alleles.

A decision on the most effective breeding method can only be made on the basis of knowledge of the genetic control of the selection characters. Very little relevant information has been published for calabrese but the available evidence and the paramount need for uniformity indicates production of hybrids as the preferred method.

We consider it important to use more efficient and defined methods in the derivation of inbred lines than the classical empirical selection for agronomic characters within inbreeding populations. Furthermore, selection from initially very divergent materials is also considered necessary. The method chosen combines these requirements, utilising assessment of parental stocks by crossing to inbred tester lines, coupled with limited inbreeding in the selected families to derive improved populations for the subsequent isolation of inbred lines. Some experimental populations were grown in 1976 and crossing to testers is now in progress.

"NEO-CALABRESE" - A PROGRESS REPORT

Elaine Sanders and Peter Crisp

National Vegetable Research Station, Wellesbourne, Warwick, UK

Calabrese (green sprouting broccoli) is a quick-maturing, annual form of the variety *italica* L. of *B. oleracea*. As such, it is closely related to both purple sprouting broccoli - a biennial - and to forms lacking axillary branches, such as the biennial Cape broccoli, and "purple cauliflower", which closely resembles the Cape broccoli but matures during the late autumn in Britain.

The purple sprouting broccoli is of diminishing commercial importance in Britain due, in large part, to plant to plant variability and to sequential maturation of terminal and axillary shoots which increase harvesting costs. However, it retains considerable popularity as a garden crop, where not only its maturity time (January-March) but its flavour and texture are highly prized.

The popularity of purple sprouting broccoli forms the basis of optimism for the commercial potential of calabrese in Britain. Calabrese shares the eating qualities of purple sprouting broccoli, but occupies the land for perhaps 3 to 5 months rather than nearly a year, and potentially can be harvested in a few cuts if grown as a close-spaced crop from which only the terminal heads are taken. The extensive breeding of calabrese by the Americans and Japanese have added to this potential of the crop by revealing tantalising indications of substantial plant to plant uniformity achieved by inbreeding and F_1 hybrid production.

In order to produce a marketable size, the calabrese heads must be allowed to develop to the stage when the flower buds are near anthesis. This may result in the buds opening precociously, or in a proportion of them dying ("brown bud"). Additional risks of harvesting the plant at this late developmental stage include the likelihood of bracts growing through the head, of the head becoming loose as it starts to bolt, of irregularly sized flower buds, and of the disfigurement of flower buds by white blister, caused by the fungus *Albugo candida*.

Thus, despite the advances that have been made by breeding, and despite varietal differences in the expression of these defects, it appears that calabrese carries an inherent likelihood to express a wide range of defects because the head is at a late stage of development by the time that it is of sufficient size to be marketable. Faced with this problem, we constructed an ideotype of a calabrese-like vegetable. This was based upon a larger head which would give a reasonable yield at a stage when the flower buds were much younger; thus, hopefully, avoiding the defects detailed above. In addition, we decided to delete axillary branches, which might be assumed to compete with the terminal head.

The brassicas which best contributed to our ideotype were the conventional white cauliflower (*B. oleracea* var. *botrytis* L.) and the "purple cauliflower" already referred to. Both have a large terminal head and no axillary branches. Indeed, in a trial at NVRS in 1974 the purple cauliflower - despite considerable variability and poor quality - showed several other advantages over calabrese (Table 1). Hence, with the object of creating a panmix from which the appropriate recombinants could be selected, autumn maturing cauliflowers (variety Flora Blanca of Rijk Zwaan, Zaadteelt en Zaadhandel B.V.) were hybridised with purple cauliflowers (variety Sicilian Purple Late of A.L. Tozer Ltd.).

The F_1 hybrids were grown at 0.65 x 0.65 m spacing in the field in 1974. They matured at about the same time as the parents, in mid autumn, and displayed remarkable vigour and uniformity both within and between families. When assessed at the white cauliflower stage of development (i.e. head exposed, but consisting of apical meristems rather than flower buds) they had pale green heads 0.20 to 0.25 m in diameter with vegetative leaves up to 1 m in length. Within a week the heads were over 0.40 m in diameter and had developed purple colourations.

A range of these F_1s was mass pollinated, and of 528 F_2 plants grown in 1975, 21 revealed phenotypes similar to our ideotype; that is, they represented medium quality calabrese with no lateral branches and large, compact, purple/green terminal heads composed of small buds. This, of course, was encouraging; but quite unexpected was a transgressive segregation for maturity time such that these acceptable phenotypes matured over a period ranging from 69 to 256 days after sowing.

Where possible, these selected plants were again mass pollinated in order to maintain genetic variability, and a total of 16 F_3 half-sib families are undergoing selection at present. Initial results are again encouraging, with the earliest families starting to mature at 72 days, confirming the genetic component of maturity time.

Our plan is to retain as high a selection pressure as is practicable, selecting as near as possible to our ideotype. For the next generation, at least, we will mass pollinate in order to ensure recombination. Subsequently, families each representing a different maturity period will be bulked and selection will proceed on the basis of performance at close spacing (say 0.15 x 0.15 m), and on the quality of the processed head.

(We are grateful for the assistance of Elaine Roberts and Andrew Gray with this work).

Table 1 Performance of calabrese and purple cauliflower in a close-spaced trial (0.25 x 0.25 m to 0.25 x 0.15 m) at NVRS in 1974. The seed was direct drilled on 24 April. The rages of variety means are given in brackets.

character	calabrese (4 varieties)	purple cauliflower (3 varieties)
sowing to harvest (days)	107 (105 to 110)	129 (123 to 139)
yield (g per m^2)	253 (175 to 289)	788 (725 to 840)
mean quality (0 = bad, 3 = good)	2.0 (1.8 to 2.3)	1.5 (1.5 to 1.6)
% hollow stem	1.7 (0.0 to 6.4)	0.0
% brown bud	4.2 (0.0 to 9.3)	1.1 (0.6 to 2.2)
% bracted	2.3 (0.0 to 7.7)	0.3 (0.0 to 0.6)
% precocious flowers	very low incidences in this trial	
% white blister		

CLUBROOT RESISTANCE IN BRASSICA OLERACEA

S.T. Buczacki, A.G. Johnson and P.C. Crisp

As a preliminary to the possible re-commencement of work on breeding for resistance to clubroot, a collection of breeding lines was screened for resistance at the National Vegetable Research Station in 1976. These lines were from several sources as detailed below.

Until the mid-1960s there was joint work by the Plant Breeding and Pathology sections of the NVRS on breeding for clubroot resistance in cabbage and Brussels sprouts. This led to the production of breeding lines of (1) cabbage having field resistance to clubroot, some of which were approaching agronomic acceptability (Haigh & Channon; unpublished) and (2) Brussels sprout material showing good resistance in seedling tests, derived from crosses between agronomically good NVRS inbred lines and agronomically poor, but resistant material supplied by Dr. C.M. Rick, California (Channon & Johnson; unpublished). Both of these lines of work ceased with the retirement and resignation, respectively, of Drs. Haigh and Channon.

Further material had also been received from Dr. G. Weiseth, Norway and from the IVT Wageningen upon the cessation of the clubroot-resistance breeding project there. None of this additional material had previously been assessed at the NVRS for either clubroot resistance or agronomic value.

Material screened in 1976 comprised the following:-

Cabbage	19 lines ex Haigh and Channon
	14 lines ex Weiseth
	33 lines ex IVT
Brussels sprout	10 lines ex Channon and Johnson
	45 lines ex IVT
Cauliflower	50 lines ex IVT

Within each of the above groups, many of the lines were relatively closely related.

Two screenings were made, one in the field and one (including a further six *B. oleracea* types) in the glasshouse, transplants and seedlings respectively being individually inoculated with a suspension of resting spores of *Plasmodiophora brassicae* - an artificially prepared mixture of several *P. brassicae* populations. Because of abnormal weather conditions, clubroot infection developed erratically in the field trial and the plants were grown on for agronomic characters to be assessed.

In the glasshouse test the differential hosts of the European Clubroot Differential Set* were also included and all were heavily infected by the inoculum used. It was considered that the use of such an inoculum might allow for the detection of broad spectrum, non-race specific resistance, although it was intended that some lines should be further tested against individual components of the inoculum.

Results of the glasshouse test were encouraging. Even with an inoculum believed to have broader pathogenicity than any naturally occurring individual population, several lines showed very high degrees of resistance. Most notable among these were:

a. Non-hearting plants of cabbage type containing the Bindsachsener resistant source originating from Wisconsin and selected in the Haigh and Channon studies at NVRS.

b. Lines of Bohmerwaldhohl cabbage from IVT.

c. Selections from the Brussels sprout type material containing resistance derived from Badger Shipper and originating from Rick; also progeny from crosses of this material with certain NVRS inbred lines.

d. Twelve related breeding lines of Brussels sprouts containing the Bindsachsener resistance source and received from IVT.

e. Eight breeding lines of cauliflowers containing the Bindsachsener resistance source and received from IVT.

It was of interest that although many of the lines had Bindsachsener as the resistant parent, this cultivar itself did not display very high resistance. Agronomically the resistant lines were consistently of only moderate quality.

It is hoped to develop further a resistance breeding programme at NVRS incorporating some of the tested lines.

* European Clubroot Differential Set

Brassica campestris L.

ssp. rapifera line aaBBCC
ssp. rapifera line AAbbCC
ssp. rapifera line AABBcc
ssp. rapifera line AABBCC
ssp. pekinensis cv. Granaat

Brassica napus L.

var. napus line Dc101
var. napus line Dc119
var. napus line Dc128
var. napus line Dc129
var. napus line Dc130

Brassica oleracea L.

var. capitata cv. Badger Shipper
var. capitata cv. Bindsachsener
var. capitata cv. Jersey Queen
var. capitata cv. Septa
var. acephala subvar. laciniata cv. Verheul

TRANSFER OF RESTORER GENES FROM RAPHANUS TO CYTOPLASMIC MALE STERILE BRASSICA NAPUS

F.W. Heyn

In Raphanus sativus OGURA (1968) detected a system of cytoplasmic - genic male sterility, which can be applied for F_1-hybrid seed production. BANNEROT et al. (1974) introduced the nucleus of Brassica oleracea and that of B. napus into the S-Raphanus cytoplasm. The plants obtained are completely male sterile. This material was kindly supplied to me by BANNEROT in February 1975.

As Brassica napus is widely used as a grain crop, restorer genes are necessary in order to have a complete male fertility in the F_1-hybrid. Testcrosses with a large array of B. napus cultivars and accessions resulted in male sterile offspring only. The same held true for B. oleracea. This means that all euplasmic forms both of B. napus and B. oleracea are functionally maintainers with the idiotyp (F)rf rf for this form of male sterility. It seems to be highly improbable, that restorer genes could be found in B. napus or the parental species B. oleracea and B. campestris. The only way of getting restorer genes therefore is to introduce them from Raphanus. They are rather frequent in the European radish cultivars as shown by BONNET (1975).

As polyploids cross more readily than diploids, Raphanobrassica forms were chosen for this intergeneric gene transfer. The pollinators used were:

1. a hexaploid form (2n=56,AACCRR) obtained from BANNEROT, originally produced by CHOPINET,
2. a Raphanobrassica (2n=36, CCRR), which is said to be derived from the KARPECHENKO-material, and
3. a Raphanobrassica RB 5 from McNAUGHTON, Pentlandfield, (2n=36, CCRR).

All the above mentioned Raphanobrassicas are white flowering with a poor seed fertility, except the hexaploid form, which is fairly selffertile and which sets seed to a satisfying extent.

Pollinations were carried out in insect proof cages every second day with open flowers only. Seed set on the cms B. napus plants was poor, but as several thousand pollinations could be done without great expenditure, the quantity of B. napus-Raphanobrassica-hybrids was reasonably high. 22 successfully pollinated cms B. napus plants gave rise to 331 male fertile white flowered hybrids with the hexaploid CHOPINET-form. The florets of the F_1-hybrids, whose genome constitution will be AACCR, exhaled a strong fragrance and the leaves of the plants were dark green. These characters are improved compared with those of the cms plants, which show a slight chlorophyll deficiency and a faint fragrance.

From three cms plants the KARPECHENKO-form produced 48 white flowered male fertile and 14 white flowered male sterile and 5 yellow flowered male sterile hybrids. Pollen quality and quantity was poor.

The McNAUGHTON-form produced 261 white flowered male sterile and 2 yellow flowered male sterile hybrids from 11 successfully pollinated plants. So this form does not carry any restorer genes.

The male fertile S-plasm B. napus-Raphanobrassica hybrids were backcrossed as pollen parents to cms B. napus in order to eliminate the superfluous R chromosomes not bearing the restorer genes. This is achieved by selecting for male fertility in the succeeding generations. As there is a partial homology between R, C, and A chromosomes (FUKUSHIMA 1945, MIZUSHIMA 1968) a substitution by the restorer bearing R chromosomes should be possible. An example is given by the white flowering B. napus, produced by STEFANSSON in Winnipeg, Canada. This character is conditioned by two dominant complementary genes (HEYN, unpubl.) introduced from a Raphanobrassica.

The F_1-hybrids derived from the KARPECHENKO-form did not produce any seeds on backcrossing, whereas those derived from the CHOPINET-form were successful. Additionally the restorer genes were crossed into a F-plasm B. napus, and the resulting hybrids crossed with cms B. napus again to allow selecting for restoring ability again. One of the resulting male fertile offspring was a very efficient pollinator: the seed set on one cms plant was 41 siliquae containing 421 seeds (10.7 seeds per siliqua on an average). There are several plants more with a similar seed set, which will be harvested in the next time.

The procedure till the present state is as follows:
(The genomes are denoted in capital letters, the plasmotyp is given in brackets).

(S) AACC x AACCRR male fertile, white flowers
↓
(S) AACC and (F) AACC x (S) AACCR male fertile, white flowers
↓
(S) AACC x (S) AACCR' and (F) AACCR' male fertile, white flowers
↘
(S) AACC x (S) AACCR' male fertile, white flowers
↳ e.g.: one plant with 10.7 seeds per siliqua

Probably it will take about three or four further generations of backcrossing and selfing for recovering full female and male fertility in the restorer lines.

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FERTILITY RESTORATION OF EUROPEAN RAPESEED CULTIVARS TO CYTOPLASMIC MALE STERILITY

T. SHIGA, K. TAKAYANAGI AND Y. OHKAWA

Thompson (1972)[3] found a cytoplasmic male sterility in F_2 generations of European rapeseed cultivars. We also found independently a cytoplasmic male sterility in the progenies of intraspecific cross between two Japanese rapeseed cultivars (Shiga and Baba, 1973)[1]. We tested 131 Japanese rapeseed cultivars for fertility restoring ability to our male sterile cytoplasm and classified them into three groups, i.e. 23 fertility restoring, 79 partially restoring and 29 non-restoring groups. According to the differences in cytoplasm (S or N) and the number of restorer genes (I,II, III & IV), we could classified rapeseed cultivars into 9 classes, i.e. S-0, S-I, S-IIa, S-IIb, S-III, S-IV, N-0, N-I and N-II (Shiga, 1976)[2].

This paper deals with fertility restoring ability of 71 European rapeseed cultivars. These materials had been sent to us from Drs. F. Hyne, G. Rakow, M. Bechyne, L. Bengtsson and B. R. Steffansson. We wish to express our sincere appreciation to them for their kindness.

We conducted following four test crossings, 1) male sterile line (S-0) X European cultivars, 2) European cultivars X male sterile line (S-0), 3) European cultivars X Isuzu-natane (N-0) and 4) European cultivars X Bronowski (N-0). Calculating the fertility indeces of European cultivars and F_1 hybrids derived from each test-cross (Table), we devided European cultivars into three groups; fertility restoring group including 62 cultivars having 46 or more fertility index (F.I.), partially restoring ones including 4 cultivars having 21 to 45 F.I., and non-restoring ones including 2 cultivars having less than 20 F.I.. From this result we assumed that some of the cultivars tested could be determined to belong to each one of 9 classes mentioned above, i.e. Liho(145) belongs to S-I, Crésus(168) to S-I or S-II, Victoria(159) to S-IIa, Regina II(146), Mlochowski(149) and Linola(179) to S-IIb, Bronowski(150) to N-0, Erglu(185) and Eckendorfer Mali(200) to N-I, Target(142), Norde(170), Mali(182), Gulle(202) and Germany(203) to N-II. However, most of the cultivars tested could not be distinguished from this result.

European cultivars used in this experiment are shown below with the code number: 138 Ceská, 139 Třebićska, 140 Slapska, 141 Oro, 142 Target, 144 Janetzkis Weithenstephaner, 145 Liho=Petra, 146 Svalöfs Regina II, 147 Späts Zollerngold, 148 Komet, 149 Mlochowski, 150 Bronowski, 151 Kutkowski, 152 Krapphauser, 153 Lembkes Malchower, 154 Quedlinburger Platzfester, 155 Ölquell, 156 Fertödi, 157 Regal, 158 Nugget, 159 Svalöfs Victoria, 160 Maris Haplona, 161 Tonus, 162 Marcus, 163 Titus, 164 Tanka, 165 Nilla=1022, 166 Gylle, 167 Rigo, 168 Cresus, 169 Nilla(glossy leaf), 170 Norde, 171 Mali, 172 Janetzkis Sommerraps, 173 Midas, 174 Turret, 175 Wielkoposki, 176 Erra, 177 Erle, 178 Lifura, 179 Linola, 180 Matador, 181 Linus, 182 Mali, 183 Omi, 184 Petranova=Lihonova, 185 Erglu, 186 Zephyr, 187 Gorczański, 188 Szneszowicki, 189 Warczawski, 190 Polnoślaski, 191 Armander, 192 Expander, 193 Niederarnbacher, 194 Panter, 195 Salamander, 196 Synra, 197 Major, 198 Borowski, 199 R Janus, 200 Eckendorfer Mali, 201 R Crésus, 202 SV Gulle, 203 Germany, 204 Rapol, 205 Diamant, 206 Lenora, 207 Lesira, 208 Tower, 215 Target.

Table. Fertility indices* of European rapeseed cultivars, 68 hybrids between MS and European cultivar, 42 hybrids between European cultivar and MS;** 29 hybrids between European cultivar and Isuzu-natane, and 69 hybrids between European cultivar and Bronowski. Cultivar numbers are shown in bold numerals corresponding to the cultivar name shown in the text.

F.I.	Cultivar	(MS X Cult.)F_1	(Cult.X MS)F_1	(Cult.X Isuzu)F_1	(Cult.X Bron.)F_1
- 0		145,150			
0- 5					
6-10					
11-15					
16-20				145	
21-25					
26-30		200			
31-35		168			
36-40		171			
41-45		185			
46-50		142			
51-55					
56-60		159,182			168
61-65		202			145,149
66-70		146,203	149	146	146,179
71-75		140,148,169,188			
76-80	156,168	151,165,179,193	168		159
81-85	172,179	149,152,160,164 172,183,186,192 207,208,215	139,151,156,157 159,162,178	166	156
86-90	145,146,147,149 155,157,158,159 160,166,173,176 189,190,191,207 208	139,147,153,154 155,156,157,163 166,167,173,178 181,184,187,189 190,191,196,197 204	140,154,155,176 181,184,187,190 192,198,207	160,173,183,186 208	142,147,151,152 153,157,160,162 166,167,169,173 181,186,190,193 205
91-95	138,140,141,142 144,148,150,151 152,153,154,161 164,165,167,169 170,171,174,175 178,181,183,185 186,192,193,200 201,202,203,204 206,215	138,141,161,162 170,175,176,177 180,194,195,198 199,201,205,206	152,153,163,175 177,180,185,188 189,193,194,196 197,200,203,204 205,215	147,158,165,167 171,174,191,202 215	138,140,144,150 154,158,161,163 164,165,170,171 172,174,175,176 177,178,180,183 185,187,191,192 197,201,203,204 207,208,215
96-	139,162,163,177 180,182,184,187 188,194,195,196 197,198,199,205		148,161,170,195	138,141,142,144 150,164,169,172 182,199,201	139,148,155,182 184,188,194,195 196,198,199,200 202,206

* ; Fertility indices are calculated from the relative position of anther to pistil and petal width, details in Shiga (1976).

**; with pollen grains bearing under hot green house or bearing in the late flowering stage.

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BRASSICA SEED GERMINATION AND SEEDLING EMERGENCE

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The increasing use of hybrid Brassicas, the rising cost of such seed and preference for direct drilling over transplanting, all call for the use of high quality seed of uniform superior field establishment. A project was initiated at the SHRI in 1975 to study the laboratory germination and field emergence of Brassicas. The first year experiments have been conducted on brussels sprout and kale seed.

Sprout: - Forty-nine seed lots from 42 cultivars were tested of which 17 were hybrids. Germination levels were extremely variable e.g. 36-100% (mean 82.5%) at 20^{o}C and 12-96% under moisture stress (mean 60%). A significant seed lot x stress interaction was present, seed lots responding differently to different stresses. Field emergence levels were also variable (6-83% over 4 sowing dates) and usually much lower than germination levels, (mean 52%). A significant seed lot x sowing date interaction was found.

Although some F_1 seed stocks had poor emergence and germination levels, it seems significant that of the 10 seed stocks with mean emergence levels more than 70%, 9 were hybrids. While this may reflect more careful production methods it may also indicate genetic superiority (Hodgkin & Hegarty, 1976). Germination at 20^{o}C correlated well with field emergence, but the germination test would not be used to predict emergence. Its value was more that of a ranking indicator, with the high-germinating stocks. ($>$90%), especially amongst the hybrids, giving more consistent emergence.

Four stocks of one open-pollinated cultivar showed a wide range of germination and emergence levels, with variable response to stress conditions.

Kale: - Seed of F_1 cultivars is often produced at a number of sites representing a wide range of environments and production techniques and giving a range of yields and seed characters. Sixty-seven seed lots of one hybrid kale cultivar produced at different sites, of germination levels of 60-95%, were used in a field emergence trial. Emergence levels (over 3 sowing dates) varied from 49 to 93% (mean 80%) and only eight seed lots gave less than 70%. Six of these 8 lots gave inferior germination (60-73%). Seed lot x sowing date interaction was again significant.

Generally the variability in the kale material was much less than in the sprout lots and the germination and emergence levels were much higher. This relatively high quality of seed lots - in spite of diverse sites and methods of production - suggests that environmental factors by themselves are not sufficient to explain the variability observed in the sprout lots. It may be that with the increasing cost of seed the breeders will soon have to focus attention on ensuring better seed quality and higher emergence levels.

One of the difficulties encountered in this research has been obtaining sufficient quantities of seed of known history. The author would welcome any offers of such seed including e.g. seed of different genotypes produced in similar known environments, of the same genotype produced in different environments or of parent lines and their F_1's.

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PROGRESS TOWARDS INTER-SPECIFIC HYBRID FORAGE RAPE

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The possibility of producing inter-specific hybrids between turnips (B.campestris L., 2n = 20, aa) and rapes (B.napus L., 2n = 38, aacc) is the subject of a feasibility study at this institute (Mackay, 1973).

As a first step, S allele homozygotes of turnips have been isolated to produce F_1's for use as seed parents in combination with rape pollen donors. The inbreeding, necessary to isolate these S homozygotes, results in severe depression in vigour and fertility; of 30 S alleles recognised to date only 16 survive as extant lines. Difficulties in maintaining the turnip inbreds serve to underline the fact that production of hybrids, using only the turnips as seed parents, would be uneconomic. However, a number of self-incompatible rape lines are now available (Mackay, 1976) and it will be possible to produce hybrids using both species as seed parents, in the near future. Since rape tends to be a more productive seed parent than turnip and is tolerant of inbreeding, this should greatly alleviate seed production problems.

Six "hybrid rapes" (2n = 29, aac), produced from turnip F_1's and self-compatible rape pollen donors in insect cages, are being harvested from a replicated trial (October, 1976). Data are not yet analysed. Their performance, as far as can be assessed by visual observation, compares favourably with the true rape and stubble turnip controls.

In 1975 sufficient F_1 turnip seed was produced to sow 5 large (80 m^2) isolation plots in Autumn 1976. In 1977 these multiplications should provide information on seed production, under conditions more akin to those of commercial practise, and sufficient "hybrid rape" seed for large scale multi-site assessment of agronomic performance in 1978.

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THE POSSIBILITY OF LEAFY, BIENNIAL RADISHES FROM HYBRIDIZATION OF RAPHANUS SATIVUS (FODDER RADISH) AND R. MARITIMUS (SEA RADISH).

I. H. McNaughton.

Fodder radish, a form of R.sativus L., is alleged to have emanated from France as a leafier selection from oil-seed radish, still grown as such in parts of Eastern Europe and in Germany as a green manure crop.

The first fodder radish cultivars, introduced into Britain about 18 years ago, were prone to early flowering, a relic of their ancestry, this resulted in stemmy growth and poor utilization on grazing; they also lacked frost hardiness. There was evidence, however, of resistance, in the field, to Plasmodiophora and Erysiphe, and, unlike brassicas, fodder radishes did not multiply sugar beet eelworm.

More recent cultivars, such as Slobolt (Deal, Cullen Seeds Ltd.), Nerys and Rodric (Welsh Plant Breeding Station) are less prone to early flowering, but are not the complete answer to the problem. Hailstone, a 'turnip-rooted' radish (Deal, Cullen Seeds Ltd.), appears to be biennial and hardy but is deficient in yield. A prospective new tetraploid cultivar, Crail, developed at Pentlandfield, is a considerable improvement in being productive and virtually non flowering from normal, late June to July sowings, but, in lacking winter hardiness, cannot be regarded as a biennial. Late flowering annuals can create difficulties with regard to seed production.

R.maritimus Sm. (the sea radish), distinguishable from R.sativus mainly on siliqua and leaf characters, is a fairly common biennial or perennial weed of coastal areas, described as 'a plant of the drift-line and cliffs, on sandy and rocky shores'. It has a distribution in Britain from Argyll and Durham southwards (Clapham et al, 1962).

R.sativus and R.maritimus have previously been reported to cross. Both are recorded as possessing 2n = 18 chromosomes (Clapham et al, loc. cit.).

R.maritimus was collected, as cuttings, from the shore of The Gareloch, Argyll, West of Scotland in October, 1970. Cuttings were rooted and plants retained in a cold frame, they failed to flower until Spring 1972 when they were crossed reciprocally with R.sativus Cv.Slobolt and with a later flowering selection, developed at Pentlandfield by rigorous mass selection from Slobolt. Hybrids were produced very easily with R.sativus as female parent, less readily from the reciprocal cross.

Cross	No.pols	No.seed	Seed/pol.	Seed/siliqua
R.sativus X R.maritimus	919	2716	2.96	4.18
R.maritimus X R.sativus	710	97	0.14	1.00

F1 hybrids, together with their parent species, were transplanted to the field in July, 1972.

R.sativus plants commenced flowering after about 7 weeks, the selection from Slobolt flowering two to three weeks later than the cultivars.

R.sativus did not survive the winter. F1 hybrid R.sativus X R.maritimus plants proved leafy, vigorous and winter hardy, showing no signs of flowering in autumn-winter, 1972-73. Most R.maritimus plants died back to a basal rosette and generally lacked the vigour the species shows in its natural environment. A few failed to survive, probably due to the fact that R.maritimus is, reputedly, a halophyte (salt lover) and not due to lack of frost resistance.

Meiosis in F1 hybrids was examined. Chromosome pairing and segregation in P.M.C.'s was perfect.

	9_{II} at M_I	9:9 segregation at M_{II}	9:9:9:9 segregation at T_{II}
Nos. of cells examined	135	284	129

Hybrids have been back-crossed to R.sativus in order to introgress the biennial habit into fodder radish without the halophytic tendency of the sea radish. Hybrids were colchicine treated and the back-cross also effected at the tetraploid level, with the object of producing an improved parent for Raphanobrassica synthesis (see McNaughton, 1973). The possibility of a leafy, biennial radish cultivar is also in prospect.

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CURRENT PROSPECTS FOR RAPHANOBRASSICA AS A NEW CROP PLANT

I. H. McNaughton

The intergeneric amphidiploid, Raphanobrassica, was first formed following spontaneous chromosome doubling of hybrids between Raphanus sativus (an oil-seed form) and Brassica oleracea (Brussels sprouts, cabbage and kohl-rabi) (Karpenchenko, 1924). It proved of considerable academic interest and is quoted in text books as a classic example of an amphidiploid. Detailed morphological and anatomical studies were made but Raphanobrassica has not, as far as is known, been exploited as a horticultural or agricultural crop plant.

In 1968 the first crosses were carried out at Pentlandfield with the aim of combining the vigour and disease resistance of fodder radish with the hardiness of fodder kale. F1 hybrids, produced as a result of crossing colchicine induced autotetraploids, varied considerably in vigour, approx. 20% being stunted and deformed, many, otherwise normal plants, producing no pollen, whilst some had reduced female parts. On selfing, or inter-crossing, pollen fertile plants only .07 and .08 seeds per pollination (.20 seeds per siliqua) were obtained, in spite of good chromosome association (McNaughton, 1973 a)

From F2 generation to F5 Raphanobrassica plants have been grown as transplants, at regular spacing in the field, and selection made for vigour, lack of premature flowering, uniformity within each family and for seed fertility.

In 1972 sufficient seed was available to carry out Plasmodiophora resistance tests under controlled conditions, resistance to N3 sensu Johnston (1970) was shown. (McNaughton, 1973b). Tests, carried out in 1974-75, have demonstrated resistance to Plasmodiophora populations giving an ECD 21/31/31 reaction sensu Buczacki etal (1975), i.e. attacking 13 of the 15 European Club-root Differential Set. In a very recent test, carried out at N.V.R.S., Wellesbourne (Buczacki, personal communication), one Raphanobrassica family was immune to an artificially constituted inoculum, or 'soup', giving an ECD 31/31/31 reaction, i.e. attacking all 15 ECD hosts. Other families showed a high degree of resistance.

Resistance to powdery mildew (Erysiphe cruciferarum) has been shown in the field at The Murrays, East Lothian, in 1974-6 and also at N.I.A.B., Cambridge, in early sown, mildew tests in 1975 and 1976 (Dixon, personal communications). A few plants showing hypersensitive reactions were reported by N.I.A.B. Plants overwintered in the glasshouse, by N.S.D.O., Cambridge, for seed production were quite heavily infected by Erysiphe in 1976. Some infection on the flowering stems of plants in multiplication plots has been noted at Pentlandfield.

Vigour, lack of flowering, uniformity and seed fertility have all responded to selection. Thanks to a multiplication, carried out by Dalgety and Co. in New Zealand, sufficient Raphanobrassica seed was available in 1975 to carry out drilled experiments with two sowing dates at four sites. From early July sowings, Raphanobrassica was superior in dry matter yield to giantrape, cv. Lair, by almost 25% and higher yielding than Nevin rape by almost 40% (means of 4 sites). From early August sowings, however, Raphanobrassica was considerably outyielded (as were the rape cultivars) by Ponda stubble-turnip and by Appin (S.P.B.S.).

Observations on discard drills of trials in 1975 indicated no problem of acceptability of Raphanobrassica, but further evidence is needed. An area of approx. .5 ha has been sown by A.D.A.S. in North Humberside to evaluate grazeability and live weight gain by sheep. A number of other trials and observations are currently being carried out at sites throughout U.K.

Results, obtained, so far, clearly indicate the potential of Raphanobrassica as a possible replacement for rape, in terms of disease resistance and yield; seed fertility is not yet, however, at a sufficiently high level for it to be a commercial proposition.

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Seeds of any Brassica oleracea mutants would be welcome to increase the range of genes available for linkage studies. Mutants from the SHRI collection are available on request.

A.B. Wills

SIB CONTENT ESTIMATION IN F_1 CULTIVARS

A.B. Wills, Eveline M. Wiseman and Sheena K. Fyfe

Research on the possible use of isoenzyme analyses of individual seeds as a means of routine estimation of sib content in seed of F_1 cultivars has been in progress since 1972, following the suggestion by te Nijenhuis (1968, 1971). Two major problems have been investigated: (i) development of reliable, rapid, low-cost methods and (ii) the identification of suitable enzyme systems; since the apparently high costs and inability to assess all cultivars were discouraging acceptance of the technique by breeders.

Electrophoresis on polyacrylamide gels was chosen for isoenzyme separation because of the simplicity and wide applicability of the technique in addition to excellent gel clarity. In order to reduce costs it was necessary to simplify the usual lengthy laboratory procedures of grinding and centrifugation in the preparation of sample extracts and also to increase the number of samples analysed in each electrophoresis run. It was shown that crude extracts of crushed seeds could be applied directly to the gels with acceptable results for several enzymes tested and, by simple modifications to commercially available apparatus, capacity has been increased to 160 seeds analysed per day by one worker. Despite simplification, extraction procedure has again become the limiting factor. If this limitation can be overcome it is thought that capacity could be further expanded to 240 samples per day.

The results reported for acid-phosphatase (AP) by te Nijenhuis have been confirmed. The fraction of interest comprises a total of four bands with mobilities from 0.25 to 0.34 relative to brilliant yellow tracker dye, resulting from the action of four co-dominant alleles at a single locus. Null alleles have not been found. The band of greatest mobility occurs only rarely and has not been found in Brussels sprouts or any of the hybrid cabbage cultivars tested.

Successful sib detection is restricted to these cultivars with parents not having any allele in common. To overcome this restriction a wide range of other enzymes has been examined. None of these has proved to be as useful as AP and they have been discounted for routine use although esterase and amylase, in particular, gave interesting polymorphisms that could be used in testing a limited number of cultivars. A more rewarding approach has been to examine cotyledons of young seedlings, where it was found that many more AP bands were resolved. Among these two separate groups of bands are each controlled by a single gene and two alleles have been identified for each of these genes. These simple systems are highly suitable for the routine testing envisaged and by using either seed or cotyledon AP analysis sibs can now be recognised in more than 70% of the hybrids examined.

It is considered that the precision and rapidity of this biochemical testing method, taken with the minor cost relative to the value of a seed crop, now justify its use on a routine basis. To enable breeders to assess the system against their present methods a pilot testing scheme was set up and British and some other organisations were invited to submit seed for testing at an economic fee. An encouraging response was received which, it is hoped, will lead to commercial adoption of the technique.

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If any brassica breeders/researchers have experience in growing turnips (B.campestris L.ssp.rapifera), or closely related material, in totally artificial, controlled environment conditions; G.R. Mackay of the Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian, Scotland, would very much like to establish contact. Our stocks seem extremely "light sensitive" and initial attempts have failed due to rapid chlorosis, which we have been unable to prevent under various light regimes (further details on request).

THE ROLE OF POLLEN AND STIGMA IN PARTIALLY COMPATIBLE POLLINATIONS

T. Hodgkin

Introduction

The level of partial-self-compatibility in brussels sprouts is often attributed to the extent to which the stigma fails to inhibit pollen tube growth and penetration. Experiments conducted at S.H.R.I. suggest however that both pollen and stigma play a part in determining the observed level of partial-self-compatibility and that they operate independently.

Materials and Methods

Plants from three inbred families, obtained by selfing single plants, were used in five separate experiments. In each of four of the experiments a number of plants from one family were intercrossed in all possible combinations and in the fifth, plants from different families were intercrossed. For each experiment stigmas from one-day-old flowers of all the plants used were pollinated with freshly collected pollen separately bulked from each plant and applied with a small brush. Between three and five flowers were used in each pollination (a constant number for each experiment) and all pollinations within an experiment were made on the same day, collected the following morning, and fixed in chloroform-acetic-alcohol. The number of pollen tubes penetrating the stigmas was determined using the method described by Van Hal and Verhoevan (1968).

Analysis

Pollen tube numbers were transformed to logs and an analysis of variance was performed to determine the presence of significant between cross differences within each experiment. There were always highly significant between cross differences when compared to variation between individual pollinations within a cross.

There were considered to be three sources of variation between crosses - that between plants used as pollen donors (pollen source) that between the plants used as stigmas (stigma source) and that variation between crosses which could not be accounted for by the first two (interaction). While the same plants were, of course, used as pollen and stigma sources the analysis chosen treated the sources as two independent sets of factors.

Results

The three sources of variation (pollen source, stigma source and interaction) differed in their contribution to the observed between cross differences. Variation between pollen sources was always highly significant (P 0.001) as was that between stigma sources for all experiments except one. The interaction term was of less importance although often significant at the 0.05 - 0.01 level. It was apparent therefore that the number of pollen tubes in an incompatible pollination depended on the particular plant used as pollen source and that used as stigma source. The results showed further that there was more variation between pollen sources than between stigma sources. Thus the pollen used had an inherent capacity of its own to penetrate 'incompatible' stigmas and this was a major factor in determining the observed number of pollen tubes in such crosses. There were crosses which differed from the values expected from a particular combination of pollen and stigma but there did not appear to be any general pattern to such differences and they were of less importance. In particular, self pollinations were no different from incompatible crosses in the diallels.

A comparison of the values obtained for pollen and stigma sources by fitting constants from a regression analysis showed that the extent to which a plant used as pollen source produced pollen tubes was completely unrelated to the number of tubes which penetrated its stigmas. Pollen partial-compatibility and stigma partial-compatibility varied independently.

Conclusion

Both the pollen and stigmas used in an incompatible pollination play a significant role in determining the number of pollen tubes observed and variation between the pollens of different plants is likely to be greater than that between their stigmas. The extent to which pollen and stigmas from a single plant give pollen tubes in incompatible pollinations varies independently over the plants tested. Thus a self pollination, although an accurate predictor of the combined effect of both pollen and stigma, gives no information as to the contribution made by each.

Reference

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EFFECTS OF COLD- AND DAYLENGTH TREATMENT ON PLANTS OF VARIOUS AGE GROUPS OF RAPE VARIETIES.

H. KOSTER

Introduction

The destination of varieties of rape as summerrape or winterrape is a complicated matter. The requirements to those two crops depend on both farmers practice and ecological situation of the areas where the crops are used. Now and then oil crop varieties are applied as a fodder crop. Moreover good varieties tend to be applied over larger areas than was the case in former days. All those trends make the grouping of the varieties more complicated. The following experiment in the fytotron has been done to find a base for the classification as summerrape or winterrape in the intrinsic properties of the varieties.

In literature two stages are distinguished in winterrape: during stage 1 the plants are accessible to cold treatment, in stage 2 to day-length treatment; if the cold requirements of the varieties are completely fulfilled, periods of short days are dragging.

Experiment

Seven varieties of rape - varying from the easily flowering type to the extremely cold requiring type - were investigated. The age of the plants at the beginning of the cold period being 4, 6 and 8 weeks. Five weeks of low temperature (7°C) were applied. Immediately afterwards daylength treatments with 8, 12 and 16 hours periods were given.

Flowering process and observations

Because of the fact that the relation of the plantlength and the earliness of flowering is not completely understood, length of plants and time of flowering are treated separately. The plants are measured for the first time at the beginning of the cold treatment, for the second time at the beginning of the daylength treatment and for the third time after the daylength treatment of 11 weeks. The fourth measurement is done at the end of the experiment when the flowering of winterrape under natural conditions in the open starts.

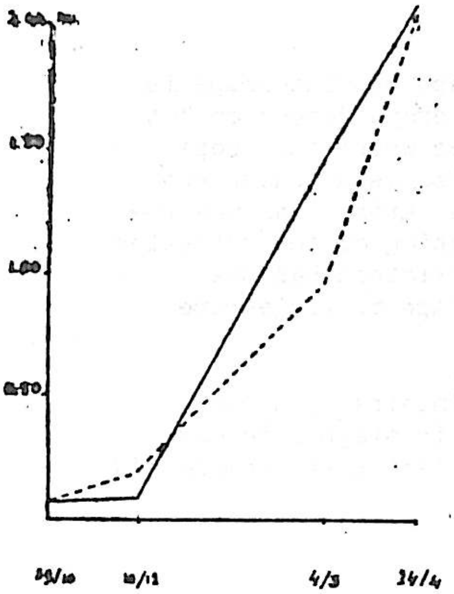
Results

Elongation

In figure 1 the average length of the oldest plants with and without cold treatment are plotted against time. During the cold treatment plants are somewhat retarded in elongation but overcompensate quickly. The total length is not, or hardly, influenced. This type of reaction occurred most often.

In figure 2 the same retardation is observed; but we did not measure any compensation. Only one variety showed this type of reaction.

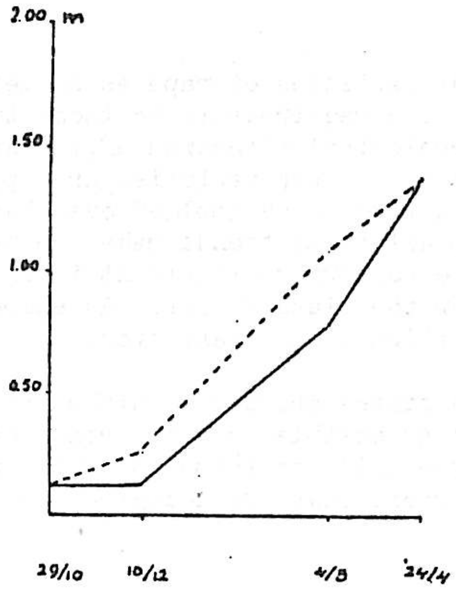
The variety in figure 3 is late with elongation; plants with cold treatment acquire a bigger total length than those without.



—— cold treatment

------ control

Fig. 1. Plantlength of TANTAL; LONTO; VELOX en EXPANDER during the experiment



—— cold treatment

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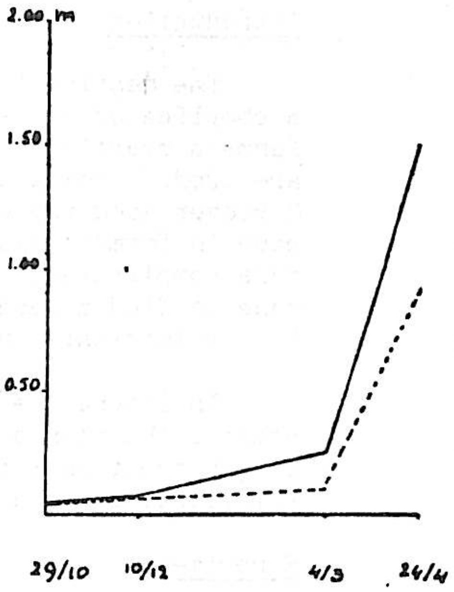
Fig. 2. Plantlength of Esora during the experiment



—— cold treatment

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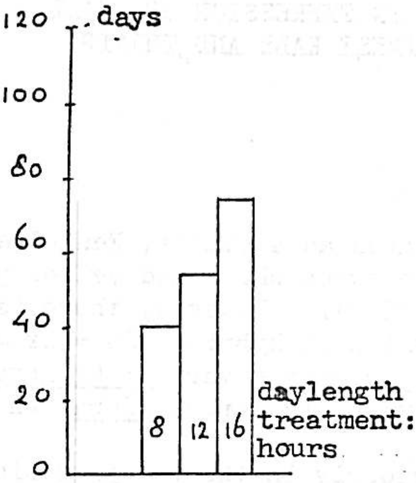
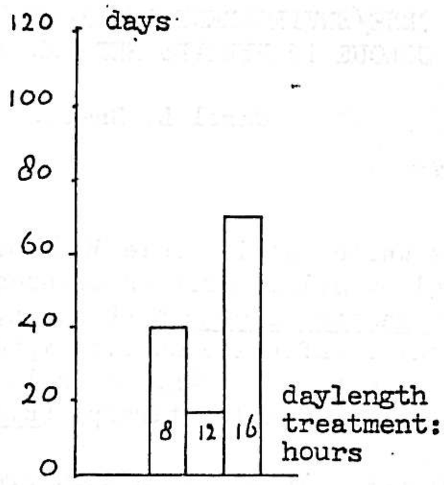
Fig. 3. Plantlength of Major during the experiment

Flowering

In figure 4 and 5 we gave the average number of days between the date the flowers open and the first of May. A quick flower reaction is represented in this way with a high value in the figure. In those figures 4 and 5 two types of reactions are represented occurring at different varieties at different ages and at treatments with different temperatures. In figure 4 a typical reaction for rape is represented; a quicker flowering response with increasing daylength. In nearly all cases where a cold treatment has been given the flowering response has been accelerated compared with the control without cold. This has not been represented in a figure.

Another type of reaction found within certain age-groups of TANTAL, VELOX, LONTO and EXPANDER shows an acceleration of flowering by longday treatment but also by shortday treatment. A possible explanation of the acceleration occurring after the shortday treatment might be that the cold requirements of those plants have not been met completely. The short day compensated in this case the lack of cold.





Time of flowering; average number of days for 1st of May

Fig. 4. A quicker flower respons with increasing daylength

Fig. 5. Daylength treatments of 16 hours and 8 hours show an accelerated flower respons compared with 12 hours

Conclusions

In this experiment we could not distinguish a separate stage accessible to cold treatment and a stage accessible to daylength treatment.

The acceleration of the flowering response after the daylength treatment with a 8 hours period may be an indication that both stages mentioned above are overlapping.

Reactions to daylength- and temperature treatments were in nearly all cases quantitative. Absence of flowering occurred mainly with AKELA and the youngest age-groups of MAJOR and LONTO.

Young plants of TANTAL, VELOX, LONTO and MAJOR have been found to be relatively insensible to flower inducing factors.

GENE/ENVIRONMENT INTERACTION IN EXPRESSION OF PETAL COLOUR IN HYBRIDS BETWEEN CHINESE KALE AND TURNIP

Carol L. Snell,

The white petal allele (Wh) behaves as a simple, Mendelian dominant to its yellow allelomorph in crosses between white and yellow petalled forms of Brassica oleracea (Pearson, 1929). However, there is a strong environmental influence on its expression in hybrids (2n = 2x = 19, ac) between white petalled Chinese kale (B.oleracea var. alboglabra, 2n = 18, cc) and yellow petalled turnips (B.campestris ssp.rapifera, 2n = 20, aa).

Chinese kale has been used previously in the re-synthesis of B.napus (2n = 38, aacc) but there seems to be no reference to this gene/environment interaction (Nishi et al, 1962).

At Pentlandfield, hybrids produced via embryo culture, which commenced flowering in August 1975, had white petals. On continuing to flower into the winter, in an unheated greenhouse, the plants progressively produced flowers with yellower petals, slowly reverting to the production of the white form as temperatures rose with the onset of summer. There was some modification at either extreme, the 'winter yellow' was paler than that of the B.campestris parent and the 'hybrid white' was distinguishable as slightly off white when directly compared with the Chinese kale's pure white petals.

No data are yet available as to the mechanism of the response, or whether light, as well as temperature, is important in the change. The white petal allele has not been reported in existing forms of B. napus (swedes and rapes) and its introduction via a Chinese kale x B.campestris hybrid may provide a useful marker gene for breeding and genetic studies.

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