RECENT DEVELOPMENTS IN RAPESEED BREEDING

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This paper gives an overall view of research into rapeseed/canola breeding presented at the eighth rapeseed congress, highlighting the main recent results.

1 - YIELD IMPROVEMENT

Significant levels of heterosis for seed yield were reported in rapeseed. The expected yield increase with the use of F1 hybrids is as high as 30 %. The G.C.A. and the S.C.A. of numerous cultivars were determined and heterosis groups were identified. But widespread commercial use of F1 hybrid cultivars requires the use of a pollination control system. S-alleles were introgressed from *B. oleracea* and *B. campestris* to *B. napus* through hybridization of parental diploid species. Two hybrid varieties produced with self-incompatibility were recently registred in Canada. The crossing rate during seed production was assessed using biochemical markers. Seed multiplication of self-incompatible lines and self-compatibility of hybrid varieties were discussed.

One of the most remarkable projects is the use of recombinant DNA technology to develop a nuclear male sterility gene (dominant) and a fertility restorer gene, both linked to easily selectable markers. Studies are ongoing to characterize this genetically modified material for the stability of the system with regard to genetic background and environmental conditions.

Several male sterility-inducing cytoplasms (C.M.S.) which could potentially be developed into CMS systems for use in *B. napus/B. juncea* F1 hybrid production have been identified. Programs have focused on the polima cytoplasm. But the *pol* cytoplasm confers both a slightly temperature-sensitive male sterility and a more or less negative effect on the yield. So hybrids produced using the *pol* system have not expressed the full level of heterosis in seed yield. Several polypeptides associated with the mitochondria of sterile plants were identified. Male sterility of the *jun* (*B. tournefortii* cytoplasm) system is more stable and partially restored F1 hybrids were observed in rapeseed. Restorer genes for this C.M.S. system are being transferred from *B. tournefortii* to *B. juncea* and *B. napus* in India. The *ogu* C.M.S. system recently improved in France for female fertility of restored F1 hybrids actually appears to be the most promising one in *B. napus* in the short term. The *ogu* system is now comlplete and workable since good female (A. lines, cybrid), maintainer (B. lines) and restorer (R. lines, a single gene linked to an isozyme marker) have been developed. A positive cytoplasmic effect of male sterile cybrids was reported.

To improve the yield potential and its stability, breeders are looking for :

- earlier *B. napus* cultivars for a wider adaptability, (by mutagenesis, interspecific crosses and haploidy),
- a better resistance to lodging through dwarfing genes,
- a better growth under low temperatures at early development,
- apetalous flowers which can increase the amount of solar radiation transmitted through the foliar canopy (this character is translated into a substantial yield advantage according to australian studies),
- resistance to herbicides by seed mutagenesis and gene transfer.

Laboratory and field screening methodologies are suggested for estimation of genetic variability for resistance to aphids or flea beetles in cruciferous species. Rapeseed populations were improved for resistance to flea beetles. Of course, the main topic concerns resistance to diseases. A wider spectrum of fungal diseases is attacking rapeseed. Blackleg resistance was introduced from *B. juncea* to *B. napus*. But new races are overcoming *B. juncea* resistance in Australia. *In vitro* selection and interspecific crosses with *B. hirta* have been developed to improve resistance to *Alternaria brassicae* in *B. napus*. The most promising route to reducing *sclerotinia sclerotiorum* seems to be to breed apetalous varieties. *B. napus* strains were resynthesized to confer resistance to *Plasmodiophora brassicae*. Genetic variability for resistance to *Albugo candida*, *Peronospore parasitica* and *Pyrenopeziza brassicae* is studied at early and late growth stages.

Leaf aliphatic glucosinolates could be involved in resistance to foliar pathogens. Serological or molecular techniques are used to analyse race structure.

II - QUALITY IMPROVEMENT

Some programs have developed *B. campestris* lines with a very low level of aliphatic and indole glucosinolates. Genetic variability for glucosinolate content in seed was estimaded in other species like *B. carinata* and *B. hirta*. *B. juncea* strains combining the double low characteristics with less pod shattering and excellent disease resistance are under development from interspecific crosses in Canada. Steady progress is also being made towards the incorporation of the yellow-seed character into *B. napus* to decrease fiber content and consequantly to increase oil and protein content. Such yellow-seeded lines are selected from spontaneous or induced mutations in *B. napus*. Interspecific crosses with related yellow-seeded species have also been undertaken. To decrease phenolic compounds (e.g. sinapine), genetic variability was assessed in *B. napus* and its parental species.

Many projects are being carried out on fatty acid composition to obtain new oils with specific nutritional and industrial requirements : higher C18:2/C18:3 ratio, low C18:3 content, low or high C22:1. In Canada a higher C18:1 mutant was obtained by seed mutagenesis in *B. napus* and then improved by crossing with low C18:3 lines using the half seed technique. This character is simply inherited, additive and stable in various environments.

A low erucic acid *B. carinita* was selected in Spain. A non-destructive analysis of fatty acid composition on microspore-derived embryos was also investigated.

III - BREEDING METHODOLOGY

Studies were presented on population improvement by S1 selection or reciprocal recurrent selection. DH and SSD populations were compared to estimate the impact of using haploidy on the long-term rate of genetic improvement. Microspore culture is now routinely used in rapeseed breeding (doubled haploid plants, mutagenesis, transformation and protoplast fusion). Studies on cytological markers of microspore-derived embryo induction are in progress. Direct transfer of 3-week-old embryos onto potting conditions has been attempted.

Interspecific crosses are widely applied for gene introgression, for instance :

- to transfer S.I. alleles from *B. oleracea* and *B. campestris* to *B. napus*,
- to obtain yellow-seeded *B. napus* from related species,
- to induce cytoplasmic male sterility,
- to improve resistance to diseases and to nematodes.

Such wild hybridizations have been carried out using embryo rescue, and symmetric/asymmetric protoplast fusion (*Arabidobrassica* hybrids). Artificial *B. napus* and *B. juncea* were regenerated. Cytoplasmic substitution was also used to improve knowledge on cytoplasmic effects. More sophisticated programs have been developed to create addition lines and the progeny of these interspecific crosses characterized for agronomical characters and for molecular markers (isozymes, RFLP...). Protoplast fusion was attempted between *B. napus/B. juncea/B. campestris* and *Capsella bursa pastoris* to improve resistance to flea beetles and to obtain freezing tolerance. The *Ogu* scheme was applied to obtain C.M.S. in *B. juncea* from *B. oxyrrhina* (chlorosis, restorer gene).

Only a few papers were devoted to gene isolation (resistance to drought). With regard to transformation, a complete nuclear male sterility system was presented. An interesting study was also initiated on the transfer of methionine or lysine rich genes. The probability of interspecific gene transfer into weedy relatives was addressed. In artificial conditions, using *in vitro* ovary culture interspecific hybrids cas be regenerated. But, the F1 hybrids were sterile r poorly fertile. In natural conditions, it appeared that wild hybridization did not occur. So the risk for natural gene transfer is very remote.

New developments may be observed in the construction of a detailed genetic linkage map (isozymes, RFLP...). Such a linkage map is interesting for :

- analysis of genetic relationships of species, cultivars and lines.
- characterization of addition lines.

An allele nom enclature was suggested of 8 enzyme systems.

Conventional breeding coupled with emerging biotechnologies will continue to play a major role in the expansion of rapeseed production. More productive and better adapted rapeseed varieties with improved tolerance to biotic and abiotic stress will be developed. Utilization of rapeseed oil for a variety of edible and industrial products and or rapeseed meal will be enhanced through compositional modifications.