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Survey on Current Rapeseed Breeding in Denmark

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In Denmark, four private seed companies are breeding rapeseed, namely MARIBO Seed, 14 Højbygårdvej, DK-4960 Holeby; Prodana Seeds A/S, 82 Odensevej, DK-5290 Marslev; Pajbjergfonden, 1 Gersdorffslundvej, DK-8300 Odder; and Dansk Planteforædling A/S, 31 Boelshøj-Højerupvej, DK-4660 Store Heddinge. Of these four companies Pajbjergfonden is breeding only spring rape. The other three companies are breeding both spring and winter rape with slightly larger programmes on winter rape (Table 1).

Table 1. Proportion of winter and spring rape breeding programme by different seed companies in Denmark.

Company	Winter rape	Spring rape
MARIBO Seed	60%	40%
Prodana Seed A/S	65%	35%
Pajbjergfonden	-	100%
Dansk Planteforædling A/S	55%	45%

Breeding Objectives

High seed yield, double low quality, high oil content, resistance to lodging and resistance to major diseases are the primary objectives in rapeseed breeding at all the breeding firms (Table 2).

Table 2. General breeding objectives for winter and spring rape.

Objectives	Winter rape	Spring rape
1. High seed yield	x	x
2. Double low quality	x	x
3. High oil content	x	x
4. Resistance to lodging	x	x
5. Resistance to diseases	x	x
6. Winter hardiness	x	
7. Earliness		x
8. High protein content	x	x
9. Short plant	x	x

The most significant diseases are Stem Canker (*Phoma lingam*), Light Leaf Spot (*Cylindrosporium concentricum*), Sclerotinia Stem Rot (*Sclerotinia sclerotiorum*) and Alternaria Leaf Spot (*Alternaria brassicae*). Intensive selection is performed against these diseases.

Fatty acid composition in the oil is another breeding objective. For example, stability of rapeseed oil can be improved by lowering the linolenic acid content. Breeding works is in progress in this area at one Danish company. In addition, at least one company is breeding high erucic acid and low glucosinolate varieties, suitable for special industrial purposes.

Yellow-seeded forms of turnip rape (*Brassica campestris*) and Indian mustard (*B. juncea*) have a high oil content in seed and a low fibre in seed meal. Therefore, yellow-seeded *B. napus* has long been a breeding objective to plant breeding firms and research organizations in Europe and in North America. One Danish company is working in this area (Poulsen et al. 1991).

Lowering the phenolic compounds of the seed meal by plant breeding is persuade by two companies in Denmark. This is expected to further improve the quality of the rapeseed meal.

Breeding Methods

Basically similar breeding methods are followed by all seed companies. However, the different companies have adjusted different breeding methods according to their breeding objective. Both the traditional pedigree and single seed descent (SSD) methods and the doubled haploid technique are commonly used. In pedigree method, single plant selection is carried out from F_2 upto F_4 or F_5 generation with the aim to develop fairly homogeneous lines. Selected lines are put into multi-location yield trial. Seed multiplication of the promising lines are performed under isolation by distance. The Single Seed Descent (SSD) method is also used up to F_4 or F_5 generation in the glasshouse. Rapid advance of generations (3-4 per year) is the important advantage of this method.

Doubled haploid (DH) technique is routinely used in rapeseed breeding by all the Danish rapeseed breeders. This allows rapid development of lines which are homozygous for all loci. Microspores of F_1 plants are cultured in the laboratory and haploid plants are regenerated. Haploid plants are treated with colchicine to double the chromosome number. The chromosome doubled plants (DH plants) are selfed and seeds are harvested. The whole process, starting from sowing F_1 plants for microspore culture to harvest of seeds from DH plants, takes about 14 months for spring rape and 20 months for winter rape. Selfed seeds of DH plants are sown in field observation plots where first evaluation is performed. Selected DH lines are tested in yield trials. One Danish DH variety is in commercial use.

Significant heterosis in F_1 hybrid is generally obtained in oilseed rape. This has stimulated all Danish plant breeding firms to breed hybrid varieties. For commercial production of hybrid seed, a pollination control system is a pre-requisite. *Napus*, *Polima* and *Ogura* cytoplasmic male sterility (CMS) are used for this purpose. Self-incompatibility (SI) offer an alternative pollination control system, however, its use in hybrid breeding in Denmark is not as wide as the CMS method. Breeding works on SI is in progress at one Danish company (Gertz 1991).

Mutation is a technique to create new variants. At least one Danish company is working in this area with good success.

Wide crosses (interspecific and intergeneric) are used in Denmark in order to transfer important traits, e.g. yellow seed coat, disease resistance, etc., into *B. napus*. For breeding yellow-seeded *B. napus* an intensive interspecific crossing programme was carried out by one

Danish company. Different *Brassica* species were involved, and embryo culture technique was efficiently utilized to generate different interspecific hybrids. Stable yellow-seeded *B. napus* genotypes have been obtained. This novel genetic source is now used in the conventional breeding programme to develop so called 'triple low' (yellow-seeded double low) varieties.

Chemical Analysis

Quality assessments are of utmost importance in rapeseed breeding. NIR is used for oil, protein, fibre and water analysis. Glucosinolate analysis is simply performed by 'strip test' followed by one of the more advanced methods: glucose release, palladium or HPLC analysis. Oil quality is measured by several breeders by GLC.

Genetic Engineering/Biotechnology

Breeding of genetically engineered plants (GMO's) is in progress in Denmark on two areas: disease resistance and herbicide resistance. At least one breeding team has successfully transformed and regenerated both winter and spring rape.

There is a general interest in the use of molecular marker system. Although these methods are still considered to be too expensive for general use in the breeding programmes.

Breeding Achievements

All four breeding companies have double low varieties of spring rape registered on the Danish as well as other countries national list of approved varieties. These varieties cover approximately 80% of the Danish spring rape areas. Two companies have also double low winter rape varieties listed in Denmark and abroad. The first Danish bred hybrid winter rape variety was entered into official tests in 1992. Several Danish bred spring rape varieties are considered very promising on the Canadian market.

One company has submitted a high erucic acid and low glucosinolate spring rape variety to official trials. Seed oil of this variety contain approximately 50% erucic acid.

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