Oil crop cultivation in Sweden

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You have already received a lot of valuable informations about oil crops and I will only complete with some informations about oil crop cultivation in Sweden.

Cultivated crops

In our country we grow both winter and summer forms of rape (*B. napus*) as well as turnip rape (*B. campestris*). White mustard is also grown but to a very limited extent, and poppy and sunflower are tested as potential new oil crops.

The oil crop cultivation started in 1940. The total oil crop acreage has fluctuated between 25.000 and 160.000 hectares and it has on an average for the past 3 years amounted to 137.000 hectares. This corresponds to about 5 % of the total arable land acreage. Winter rape and summer turnip rape occupy 40.000 hectares each, summer rape a somewhat smaller acreage and winter turnip rape about 20.000 hectares (Table 1). The relative importance of winter rape was much greater 20 years ago than today. The cultivated acreage of summer rape was very low in the early 60's and summer turnip rape became more important rather late.

Table 1. In Sweden cultivated oil crops. Average acreage in 1975-1977

	Cultivated acreage 1000-hectares
B. napus	
Winter rape	42
Summer rape	34
B. campestris	
Winter turnip rape	21
Summer turnip rape	39
S. alba	
White mustard	1

Winter rape has the highest specific yielding capacity and is the most cultivated oil crop in southern Sweden. Its winter hardiness is, however, insufficient for Central Sweden, and winter rape is here replaced by winter turnip rape. Since the winter forms have to be sown already in the middle of August it is a problem to have them to fit into the crop rotation systems. This explains why we have a comparatively large cultivation of summer rape and summer turnip rape. The rape is the highest yielding of these summer forms, but the turnip rape is earlier ripening. This last-mentioned form is, therefore, used where the vegetation period is short or when the summer oil crop has to be succeeded by winter wheat.

One of the most important reasons for many farmers to grow oil crops is the positive influence of these crops on other crops in the rotation. In southern Sweden winter rape is often sown after a crop of early ripening barley in a 4-year rotation system comprising barley, winter rape, winter wheat and sugar-beets. Winter rape can also be grown after a canning pea crop, a ley or a fallow. In Central Sweden the rotation system very often solely includes cereal crops. In such cases it is very important to alternate with an oil crop. The yield of the cereal crop may be raised with 10 % or more if grown after an oil crop.

Cultivation technique

The autumn sown oil crops are often damaged during winter, and, as a rule 10-20 % of the acreage has to be harrowed in the spring and resown with other crops. The most severe damages occur in Central Sweden. The doctor thesis of Bengt Torssell, "Hardiness and survival of winter rape and winter turnip rape", demonstrated in an excellent way the importance of the establishment of the plant stand for the overwintering of the crops (Torssell, 1959). It is, thus, very important for the overwintering to choose varieties, characterized by a low vegetation point during winter, and to adjust the sowing date and the seed rate so that the plants do not grow too tall already during the autumn.

A large number of trials have been performed by the Swedish University of Agricultural Sciences and The Swedish Oilseed Growers Association (SOC) in order to investigate the significance of different cultivation techniques on the overwintering, the yield and the quality of the oil crops as well as the value of new varieties.

One of the most important measures to achieve a good overwintering is a proper sowing date. Winter rape should in southern Sweden preferably be sown between the 10th and the 20th of August and in Central Sweden somewhat earlier. Winter turnip rape can be sown 10 days later than winter rape.

The common method for oil cultivation in Sweden was earlier sowing with comparatively large row distances (40-50 cms) followed by hoeing between rows with a tractor equipment. It has been demonstrated, however, that a change to a smaller row distance (about 12 cms) may result in a yield increase of 10-20 %, at least in winter turnip rape, summer rape and summer turnip rape (Bengtsson and Olsson, 1974). The reduced row distance has the strongest positive effect on yield in Central Sweden, where also winter rape has responded positively to this new cultivation technique. The smaller row distance is now almost exclusively adapted in the oil crop cultivation, with exception of winter rape in southern Sweden, which is still sown with a broader distance.

The seeding rate for winter rape when sown with the larger row distances is 4-8 kgs/ha. A higher seeding rate is used when the smaller row distances are applied, for summer rape for instance 12-18 kgs/ha.

The oil crops demand good supply of nutrients. The amounts of potassium and phosphorus are in the practical cultivations adjusted to the soil conditions. The amount of nitrogen fertilizers used correspond to about 135 kgs/ha of pure nitrogen, somewhat more to winter rape and somewhat less to summer turnip rape.

The possibility to make use of herbicides against weeds is much more limited in oil crops than in cereals. An important problem is therefore to find herbicides with a good selective effect between weeds and Brassica oil crops.

The harvest of oil crops is usually performed directly with the combiner. In southern Sweden, where hard winds prevail during harvest time, the winter rape is, however, mostly swathed. This swathing is performed at the yellow pod stage and the swathes are then threshed with a combiner. The yield of the oil crops has increased considerably from the starting of the cultivation up to now. This depends mainly on a better cultivation technique but also on better varieties. The mean seed yield of winter rape for the past 3-year period is 2.850 kgs/ha, that of winter turnip rape 2.240 kgs/ha, summer rape 1.750 kgs/ha and summer turnip rape 1.610 kgs/ha (Table 2). Winter rape exhibits the highest oil content, 45 %, and summer turnip rape the lowest with about 42 % in dry matter.

Damages by insects and diseases

The damages by insects are not so serious in Sweden as in many other

Table 2. Average yield for oil crops cultivated in Sweden in 1975-1977

	Average yield kgs/hectares	Oil content % in dry matter
B. napus		
Winter rape	2850	45.2
Summer rape	1750	43.5
B. campestris		
Winter turnip rape	2240	44.8
Summer turnip rape	1610	41.6
S. alba		
White mustard	1780	35.6

countries but the seed yield of oil crops can also here be drastically reduced by various insects. In addition to the common flea-beetle (Phyllotreta-species) there have been periodically strong attacks in the winter oil crops by the rape-beetle (Psylliodes chrysocephala). Before the sowing the seed is, therefore, often treated with lindan or isofenfos.

The most common of the noxious insects attacking oil seed cultivations in Sweden is the blossom beetle (Meligethes aeneus), which feeds on the young buds in the inflorescences. As a rule the blossom beetle has to be combatted once or several times during the season. The Institute for Plant and Forest Protection at the University of Agricultural Sciences is at present investigating the possibilities to develop pesticides which should be effective during a longer period of time and to define the practical threshold-values for the treatment. A newly started Scandinavian project is studying the possibilities of an integrated treatment (Nilsson, pers. com.).

The bladder pod midge (Dasyneura brassicae Winn.) is also regularly occurring, though less numerous at present than during the 40's. The midge deposits the eggs in the interior of the pods, where the larvae then develop and cause a pre-mature opening of the pods. Professor Edvard Sylvén performed in 1946-1948 a comprehensive investigation of the biology of the bladder pod midge, the damages caused by the midge and the possibilities to reduce these damages (Sylvén, 1949). He was able to verify the earlier observations made by Börner and Spreyer that the midge for its oviposition inside the pods has to rely on holes in these pods made by other insects. Sylvén was able to demonstrate that the midge, at least under Swedish conditions, is completely dependent for its oviposition on holes produced by the cabbage seed pod weevil (Ceutorrhynchus assimilis Payk). An effective combatting of the weevil will, thus, also reduce the damages made by the midge.

It is not my intention to review all the noxious insects that appear on the oil crops. However, I would like to mention that the cabbage aphid (Brevicoryne brassicae) may bring problems. The acreage of summer rape has been reduced in certain parts of northern Götaland as a result of attacks of this insect. Since this is a much greater problem in many other countries there would be much to gain from internationally co-ordinated efforts to search for resistance to this insect.

Attacks by fungal parasites are most common in southern Sweden. The development of the winter rape in the autumn may be hamperred by Peronospora. Considerable yield losses may also occur in Skåne as a result of attacks by Phoma, Verticillium and Sclerotinia. Fields may also be infected by the club root disease (Plasmodiophora).

The breeding work has hitherto included selection for resistance to Peronospora, Verticillium, Phoma and Plasmodiophora. A Scandinavian cooperative project has invented available races of Plasmodiophora and selected material resistant to the different races. Work is now in progress to transfer this resistance to material with a low erucic acid content (Jönsson, 1974).

Plant breeding

The outcome of oil crop cultivation is of course also influenced by the access of suitable varieties. Plant breeding with oil crops is performed at the Swedish Seed Association at Svalöv and Weibullsholm in Landskrona. Breeding of oil crops was carried out at Svalöv during a short period in the end of the first world war (1918-1924) under the supervision of professor Nils Sylvén. This work was resumed in 1939 and ever since that time, except for the last 3 years, this work has been directed by dr Gösta Andersson, the president of this congress. The oil crop breeding started later at Weibullsholm and has been less extensive, especially at the beginning. Agronomist Hans Svensk is at present responsible for this breeding work.

The aim of the breeding work, carried out 1918-1924 and during the 40's and 50's, was to adjust the oil crops to our cultivation conditions. Important breeding goals were improved seed yield, improved winter hardiness in the winter oil crops, earlier ripening in summer oil crops, stalk stiffness, resistance to various diseases and improved oil content in the seeds.

Fundamental research work was also carried out in connection with this breeding work.

The various modes of fertilization characteristic of the different oil crop species, were badly elucidated when the breeding work started. Several investigations demonstrated that rape is a cross-fertilizer to 1/3 and self-fertilizer to 2/3 (Olsson, 1960 a). There are marked differences between plants, and plants can be found, which are completely self-incompatible and, thus, are cross-fertilized to 100 %. White mustard as well as the turnip rape varieties, grown in Sweden, are, on the other hand, almost completely allogamous.

The possibilities to change an allogamous population through continous selection has been plainly demonstrated in white mustard. Twelve years of repeated selection raised the number of seeds per pod from 5.4 to 9.1 and the oil content from 30.0 to 37.5 % (Olsson, 1974). The oil content in summer rape has been improved after selection in crosses with winter rape.

A considerable material of artificial rape has been produced with the aim of broadening the variation in the rape material and, above all, improve the winter hardiness (Olsson, 1960b). Thus Svalöfs Norde winter rape has been selected from a cross between artificial rape and the Swedish market variety Matador.Svalöfs Norde is characterized by good winter hardiness, high yield and comparatively good resistance to Peronospora and Verticillium (Olsson, 1974 b). This variety is, however, not cultivated any more, because of its high erucic acid content.

At the end of the 50's Gösta Andersson and Lars-Åke Appelqvist started to build up a special chemical laboratory at Svalöv for the study of fat quality in the oil crops. The first investigations dealt with the influence of environment on the amount of free fatty acids and the chlorophyll in the oil. However, already in 1960 Gösta Andersson was able to report on the oil composition in the oil crops grown in Sweden, and he concluded, that one important breeding goal must be to reduce the erucic acid and improve the linoleic acid content. In connection with this he states that "The problem of the composition of the vegetable oils will most probably prove to be of immense importance for our future oil crop growing, and the breeding efforts have most certainly in the future to deal intensively with this problem" (Andersson, 1960, 1961). These predictions have indeed come true.

Thanks to a great generosity from the side of professors Downey and Stefansson we had an early access to their summer rape material with low erucic acid content. Lööf and Appelqvist were able already in 1964 to verify the earlier findings of Downey that the oil composition is determined by the genotype of the seed and not by that of the mother plant (Lööf and Appelqvist, 1964). We have also obtained low erucic acid material of summer turnip rape from Canada, however, we have also isolated such material ourselves through continous selection in Bele and Torpe summer turnip rapes (Jönsson, 1973).

The breeding work, aiming at the production of varieties with low erucic acid content, is based on crosses between the above mentioned material and well adapted Swedish material.

All our present breeding material has low erucic acid content, and of winter rape, summer rape and summer turnip rape only varieties with a low erucic acid content are allowed for cultivation. This means that the basic seed is allowed to have at the most 1 % and the certified seed 2 % erucic acid. The demand for a rapid change to varieties with a low erucic acid content has implied that the first marketed varieties have a lower yield than earlier varieties. It has, however, been possible, through continued breeding work, to raise the yield of the low erucic acid varieties to the level of the older varieties or even above this level (Table 3).

Table 3. The loss in yield and adaptation in connection with the change from high to low erucic varieties in Sweden

Variety	Erucic acid content	Oil yield Rel.	Winter hardiness	Stalk stiffness
Winter rape				
Sv Norde	High	100	87	83
Sv Sinus	Low	89	- 4	-12
WW Magnus	Low	91	-10	-11
Sv Brink	Low	95	- 2	- 4
WW 871	Low	104	- 4	- 5
Sv 749379	Low	108	+ 1	- 5
Summer rape				
Sv Gulle	High	100	-	85
CDA Oro	Low	88	-	-17
WW Olga	Low	101	-	-20
Sv Gulliver	Low	101	-	+ 2
Summer turnip rape				
Sv Torpe	High	100	-	75
CDA Span	Low	88	-	-16
Sv 7510087	Low	95	-	- 5
Sv 7510223	Low	100	-	- 8

In order to create the necessary background for the breeding work, aiming at a changed fatty acid composition in the oil crops, a number of investigations were performed, dealing with the variation in fatty acid composition within and between varieties and with the influence of climate and manuring on the fatty acid composition (Appelqvist, 1968). These studies revealed that the fatty acid composition is strongly genetically fixed, however, environment can exert a certain modifying influence. Investigations on the triglycerid composition of fatty acids from rape and white mustard have shown that the 2-position of the triacyl glycerols is almost entirely occupied by oleic, linoleic and linolenic acids but free of erucic acid (Appelqvist and Dowdell, 1968). This explains the total absence in a breeding program for high erucic acid content of lines or plants with a fatty acid composition exhibiting more than 67 mole % of the saturated and long-chain acids (Appelqvist and Jönsson, 1970).

The genetics of erucic acid content has been thoroughly studied by Roland Jönsson at Svalöv. His investigations have shown that the erucic acid content is controlled by a series of multiple alleles, which are situated in one locus in turnip rape and in two loci in rape. The correlation between erucic acid and eicosenoic acid is positive at erucic acid contents below around 25 %, however negative at higher contents (Jönsson, 1977 a).

Efforts to improve the quality of rape meal have run parallel to the breeding work aiming at lower erucic acid contents. The rape meal is characterized by a high protein content and an excellent amino acid composition. Certain sulphur compounds, the so called glucosinolates, restrict, however, the use of this meal to monogastric animals. Methods for a quantitative determination of the glucosinolate content have been developed by Appelqvist and Josefsson at Svalöf (Appelqvist and Josefsson, 1967). They have also studied the influence of the growing conditions and of the varieties on the glucosinolate content (Josefsson and Appelqvist, 1968). Investigations of the biological background to differences in glucosinolate content have proved that "the low content of glucosinolates in Bronowski rape is not due to a reduced sulphate uptake or a primarily reduced production of sulphur-containing amino acids but is caused by block(s) in the separate path-way leading to the biosynthesis of glucosinolates" (Josefsson, 1971).

In order to elucidate the feeding value of rape meal from varieties with low glucosinolate content some trials are carried out with broiler chicks at the Department of Animal Husbandry at the University of Agricultural Sciences. New investigations including cattle, pigs, hens and chickens are under way.

At the oil factory in Karlshamn a new process has been developed for the production of a protein concentrate from rapeseeds (Anjou and Fecske, 1974). Compared to soybean protein this rapeseed protein concentrate (RPC) is higher in lysine, methionine and cystine content. It has a very high nutritive value and is well suited for human consumption (Ohlson and Teär, 1974). Trials with pregnant rats have, however, shown that the phytic acid in the protein concentrate strongly binds zinc which gives an increased demand of zinc during the last days of pregnancy (Anjou, pers. com.).

The breeding work, aiming at the production of double low varieties, with a low erucic acid as well as a low glucosinolate content and with about the same yield as the existing varieties is at present the most important goal for Swedish oil crop breeding. Such varieties of summer rape are now in official trials and estimated to be marketed in 1980. Other important quality factors in the breeding are:

- Increasing the content of linoleic acid
- Reducing the content of linolenic acid
- Reduced fibre content and improved protein content in the meal
- Yellow seed coat colour

A review of the breeding for improved oil and meal quality in rape is given by Roland Jönsson in his doctor thesis (Jönsson, 1977 b).

Even though quality breeding is important and has resulted in significant improvements during the past decade, it is also necessary to have a high yielding capacity and a satisfactory cultivability in the material. It is, for instance, highly important to increase the winter hardiness and yield of the low erucic acid material of winter turnip rape.

New varieties

New varieties are usually pre-tested in trials, organized by the Swedish Oilseed Growers Association (SOC), and then, during 3-4 years in official trials, performed under the management of the Institute of Plant Husbandry at the University of Agricultural Sciences. The Governmental Plant Variety Committee will then, guided by the results from the yield trials and from the assessment of the homogeneity, stability and distinctiveness of the variety, performed by the Central Seed Testing Station, decide whether a new variety implies such an improvement as to entitle a place on the official varietal list. Only such varieties, that are on this list, are allowed to be marketed in Sweden. At present the following varieties are on this list and approved for growing on contract:

Winter rape:	Sv Brink WW Magnus
Summer rape:	CDA Oro WW Olga Sv Gulliver
Winter turnip rape:	Sv Duro Sv Rapido III Sv Solo
Summer turnip rape:	CDA Span
White mustard:	Sv Trico

Marketing

The harvested seed is delivered by the growers to a special organization, Sveriges Oljeväxtintressenter (SOI), which takes care of the drying and cleaning of the seed and the selling of it to the oil industry in the country or for export. This organization has earlier been described by Tingnell (Tingnell, 1970). The price of the seed is determined following discussions within SOI between representatives of the government, the industry and the growers. This yearly price is corrected for the individual farmer with respect to purity, water content, oil content, chlorophyll and erucic acid content of the delivered seed lot. Payment with regard to oil content was introduced already in 1956 and made possible through the routine method for oil content determinations, developed by Troeng (Troeng, 1955).

The average oil crop acreage has, as already mentioned, for the past 3-year period amounted to 137.000 hectares and the total seed yield to 256.000 tons. Of this quantity about 170.000 tons have been processed in the country and the rest has been exported. The processing has yielded around 68.000 tons of oil and 100.000 tons of rape meal. About 40 % of the produced oil is used in the country and the rest is exported in exchange of other vegetable oils.

The rape meal is only used within the country as a feed stuff for cattle. The change to double low varieties will widen the application of rape meal especially to other animals like pigs and chickens. The desire to achieve an increased fodder protein production within the country is one of the most important reasons for an expanded growing of rape and turnip rape in Sweden.

The transformation of our oil crops from types with a high to those with a low content of erucic acid, that has occurred during the past 15 years, has been a prerequisite for the Swedish margarine industry to continue to use Swedish rape oil. Thus, this transformation has also been necessary for a maintenance of Swedish oil crop growing. That this has been able to achieve so rapidly depends to a large extent on a very valuable international co-operation, and we cherish a great admiration for the pioneer work, which in this field has been carried out by Canadian plant breeders. Results obtained so far point to the possibilities of further improvement of the rape oil through an increase of the linoleic acid content and a reduction of the linolenic acid content and a further improvement of the meal of the double low varieties through a reduction of the hull content and phytic acid content and an improvement in protein and energy content. These qualitative improvements must, in the long run, be combined with higher yield and improved reliability. They will, thereby, provide a sound basis for a continued and expanded Swedish oil crop growing.

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SESSION A / SESSION A / SITZUNG A

BREEDING FOR YIELD / SÉLECTION: AMÉLIORATION DU RENDEMENT / ZÜCHTUNG: ERTRAG

CHAIRMAN / PRÉSIDENT / VORSITZENDER: J. Krzymanski

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LA SELECTION DU COLZA POUR L'AMELIORATION DU RENDEMENT

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Dans la plupart des pays producteurs de colza oléagineux, la sélection s'est définitivement orientée vers l'obtention de variétés d'abord sans acide érucique puis sans glucosinolates. Le premier objectif peut être considéré comme atteint d'une façon générale. La conversion de la production a même été souvent remarquable par sa rapidité grâce aux efforts conjugués des instances officielles de l'Agriculture et de la Santé Publique et des organisations professionnelles. La deuxième étape est déjà réalisée par les sélectionneurs de plusieurs pays, principalement sur le colza de printemps, ou en cours d'achèvement. Un effort considérable de recherche a été nécessaire pour mettre en oeuvre des solutions génétiques aux problèmes de qualité de l'huile et du tourteau que posait le colza et pour conférer aux variétés nouvelles des caractéristiques agronomiques et physiologiques égales et une productivité de même niveau que celles des variétés conventionnelles. Au cours de la prelière phase de cette transformation profonde des caractéristiques biochimiques que l'on a imposée au colza, la progression de la productivité a marqué un temps d'arrêt et une certaine régression a même été ressentie par les producteurs. Il a fallu reconstituer un rendement équivalent à celui des types normaux cultivés avant l'opération "acide érucique" puis relancer le progrès génétique.

Les débouchés importants qui peuvent s'ouvrir aux produits améliorés du colza, l'huile et le tourteau permettent maintenant d'envisager une extension de la production dans les pays qui présentent des conditions favorables à sa culture. Il faut, maintenant que ces produits sont ou vont être, par leur qualité, plus substituables aux autres oléagineux et protéagineux, rendre aussi l'économie de leur production plus compétitive vis-à-vis des autres grandes productions végétales. Et cela impose une action intensive pour l'amélioration du rendement, action qui doit passer par une remise en cause des méthodes de sélection employées jusqu'à présent, afin d'exploiter au mieux les potentialités de l'espèce.

1. RESULTATS OBTENUS DANS LA SELECTION POUR LA QUALITE ET LA PRODUCTIVITE

Dans les premiers programmes de sélection mis en oeuvre pour éliminer l'acide érucique, le géniteur généralement utilisé a été le colza découvert et généreusement distribué par les chercheurs canadiens. Ce géniteur initial présentait, de par son origine, de nombreuses caractéristiques défavorables. Les sélectionneurs ont tenté de les éliminer par des méthodes différentes : suite de rétrocroisements successifs par une variété récurrente dans laquelle on voulait intégrer les deux gènes canadiens responsables de l'absence d'acide érucique ou système faisant alterner des recroisements par une variété intéressante par sa productivité et des générations de sélection de colzas sans acide érucique de plus en plus valables au plan agronomique.

Quelles que soient les méthodes de sélection employées, les premières variétés de colza sans acide érucique ont généralement présenté par rapport aux