# Breeding for improved fatty acid composition in rapeseed (*Brassica napus* L.)

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**Abstract**

Oil of rapeseed has been used mainly edible oil from old times. Also it is used by raw materal of biodiesel for substitution of fossil fuel at present. Breeding for improvement of fatty acid composition in rapeseed has been emphasized for high quality rapeseed breeding in Korea. Most of the Asian varieties have high oil content, but lower oleic and higher erucic acid content than the European varieties. The variation in the oleic and erucic acid content in the European varieties were larger than in the varieties from Asian countries. The possibilities of isolating of a plant free from erucic acids on Asian varieties and lines were detected in study. Therefore, Canadian variety of summer rapeseed with high oleic acid and zero erucic acid was reciprocally crossed with high erucic acid varieties to introduce two recessive zero erucic acid genes to Asian varieties. It was selected 20 lines containing oleic acid over 65%. The erucic acid showed the negative correlation with oleic and linoleic acid.

**Key words**: rapeseed, *Brassica napus*, selection, high oleic acid

## Introduction

Rapeseed is one of the most important oilseed crops used as a source of vegetable oil and a substitute for fossil diesel fuel. Vegetable oils with a high content of olecic acid are of interest for nutritional and industrial purposes. The optimal composition of vegetable oils for human consumption is a compromise between the demands of nutrition physiology and the requirements of food technology. From a nutritional aspect, the content of saturated fatty acids should be as low as possible, and in this respect, oilseed rape has the most valuable oil of all major oil crops (Scarth and McVetty, 1999).

The success of the Korean biodiesel industry is dependent upon the availability of adequate supplies of reasonably priced feedstocks. The greatest experience with regard to biodiesel usage has been gained with rapeseed oil methyl ester. Due to its fatty acid composition, RME naturally has a CFPP(Cold Filter Plugging Point) value of around -10° Celsius and oxidation stability of -9 hours. The latter can be improved by increasing the proportion of oleic acid and so-called high oleic. Low linoleic types have now been bred. However, a change in the fatty acid pattern in compliance with the requirements of the automotive and mineral oil industries would result in change to harvesting, storage of rapeseed and logistics and thus incur higher costs. The oil contents of fundamental significance and in the future, is likely to become the competitive factor on international markets.

Reduced levels of polyunsaturated fatty acids and the resulting increase in the level of the monounsaturated oleic acid are associated with a higher oxidative stability and reduced oxidation products in the oil without need for extensive hydrogenation (Schierholt et al., 2001). A diet containing a high content of oleic acid can reduce the content of the undesirable low-density lipoprotein cholesterol in blood plasma (Grundy, 1986) and monounsaturated fatty acids more effectively prevent arteriosclerosis than polyunsaturated fatty acids(Chang and Huang, 1998). Genotypes with increased oleic acid content have been reported for several oil crops, such as *Glycine max* (L.) Merr. (Takagi and Rahman,1966), *Brassica rapa* L. (Tanhuanpää et al., 1966), *Brassica carinata* A. Braun (Velaco et al., 1966), and *Brassica napus* (Rücker and Röbbelen, 1995).

The objective of this study was to search high oleic acid line from improved germplasm which was selected lines with zero-erucic acid and low-glucosinolate suitable as edible oil through pedigree breeding method from 1970 to 1990. We will make restore line use of high oleic acid line for developing $F_1$ hybrid.

## Materials and method

Breeding for improvement of fatty acid composition in rapeseed has been emphasized for high quality rapeseed breeding in Korea. In 1970's, it was established breeding program in order to develop variety with zero-erucic acid and low glucosinolate which is suitable as edible oil. We should introduce variety with good quality oil from oversea including Germany, Canada, France, Japan, and Poland. Most of the Asian varieties have high oil content and were lower oleic and higher erucic acid content than the European varieties. We were used good quality varieties such as 'Oro', 'Bronowski', 'Erra' and 'Tower'.as crossing parents.

The possibilities of isolating of a plant free from erucic acids on Asian varieties and lines were detected in study. Therefore, Canadian variety of summer rapeseed with high oleic acid and zero erucic acid was reciprocally crossed with high erucic acid varieties to introduce two recessive zero erucic acid genes to Asian varieties.

A rapid testing technique of fatty acids and effective early selection of superior individual plants with good quality oil in the segregation populations through analyzing germinated cotyledon of rapeseed by paperchomatography was developed and utilized at the Mokpo Experiment Station in Korea.

The rapid analysis of fatty acids by paperchromatography has been practiced using outer cotyledon germinated and safe nurturing of selected individual plants through green plant vernalization under the low temperature conditions. Half of the outer cotyledon germinated was sampled to analyze fatty acid composition, resulting in complete and safe nurturing of the individual plants selected during the green plant vernalization period. The quarter cotyledon technique was the best for growing healthy seedling of the selected plants, but half seed technique was poor in growing the seedlings.

So we were developed a lot of lines with good quality of fatty acid and spread adoptable cultivars in southern region of Korea.

Recently, rapeseed has been important vegetable oil crop as the advent of biodiesel. Potentials for raw materials for the production of biodiesel is supported by increasing the proportion of oleic acid in rapeseed. It was selected 20 lines containing oleic acid over 65%. The erucic acid showed the negative correlation with oleic and linoleic acid.

## Results

Lines of #76152 were selected through single cross between Brnowski(♀) and Erra(♂). Line of #76157 was selected through single cross between Oro(♀) and Bronowski(♂). Line of #76161 was selected through single cross between Oro(♀) and Erra(♂). Line of #78113 was selected through three way cross of Oro//(Erra/Bronowski). Lines of #82009 was selected through four way cross of (Lesira/Erra)//(Oro/Tower). Line of #82015 was selected through three way cross of Mangunjaelae(local variety)//Erra/Tower.

YL-MB-60-3-2-3 was selected through mutation breeding by using X-ray.

The oleic acid content of 82009-B-101-1-1 was highest among 20 lines with selected high oleic acid. The content of linoleic acid and linolenic acid was decreased little by little according to increase the content of oleic acid. The oil content of selected 20 lines showed ranges of 44-45% (Table 1).

**Table 1. Fatty acid composition and oil content of selected line.**

| Lines | Oil content(%) | PAL | STE | OLE | LNL | LIN | EIC | ERU |
|---|---|---|---|---|---|---|---|---|
| 76152-B-2-4-2-8 | 45.1 | 3.7 | 1.7 | 65.6 | 19.8 | 7.9 | 1.2 | 0 |
| 76152-B-2-8-2-2 | 44.7 | 4.0 | 1.4 | 65.0 | 20.3 | 8.7 | 0.5 | 0 |
| 76152-B-2-8-3-6 | 44.8 | 3.7 | 1.7 | 65.0 | 20 | 8.9 | 1.5 | 0 |
| 76152-B-2-8-4-2 | 45.3 | 3.7 | 1.5 | 65.2 | 19.4 | 7.7 | 2.5 | 0 |
| 76157-B-4-4-1-7 | 45.2 | 4.3 | 1.7 | 64.3 | 22.3 | 6.2 | 1.2 | 0 |
| 76161-B-2-2-2-6 | 44.5 | 4.3 | 1.5 | 70.4 | 15.4 | 7.1 | 1.2 | 0 |
| 78113-B-6-3-1-1 | 45.3 | 3.8 | 1.5 | 67.1 | 18.8 | 7.5 | 1.3 | 0 |
| 82009-B-101-1-1 | 44.6 | 4.2 | 1.4 | 72.0 | 15.8 | 5.4 | 1.3 | 0 |
| 82009-B-108-1-2 | 44.3 | 3.2 | 1.4 | 70.6 | 16.7 | 6.8 | 1.2 | 0 |
| 82009-B-108-3-2 | 44.5 | 3.9 | 1.3 | 70.9 | 16.3 | 5.9 | 1.6 | 0 |
| 82009-B-111-1-2 | 44.6 | 4.5 | 1.4 | 70.5 | 17.4 | 5.1 | 1.1 | 0 |
| 82009-B-111-1-5 | 44.3 | 3.9 | 1.2 | 71.9 | 16.3 | 5.6 | 1.1 | 0 |
| 82009-B-77-1-1 | 44.7 | 4.3 | 1.4 | 66.2 | 20.4 | 6.5 | 1.2 | 0 |
| 82009-B-82-1-1 | 44.3 | 4.2 | 2.1 | 69.1 | 19.7 | 3.8 | 1.0 | 0 |
| 82009-B-89-2-2 | 45.1 | 3.7 | 1.5 | 71.7 | 15.7 | 6.2 | 1.2 | 0 |
| 82009-B-96-2-1 | 45.2 | 3.8 | 1.5 | 67.6 | 18.7 | 7.2 | 1.1 | 0 |
| 82009-B-98-1-2 | 44.2 | 4.6 | 1.6 | 67.6 | 18.4 | 6.3 | 1.5 | 0 |
| 82009-B-99-1-2 | 44.7 | 4.1 | 1.3 | 70.9 | 16.9 | 5.8 | 1.1 | 0 |
| 82015-B-2-2-2 | 44.7 | 4.0 | 1.3 | 69.5 | 16.0 | 7.9 | 1.3 | 0 |
| YL-MB-60-3-2-3 | 44.5 | 2.6 | 2.3 | 65.0 | 20.8 | 7.6 | 1.7 | 0 |

Note: PAL: palmitic acid, STE: stearic acid, OLE: oleic acid, LNL: linoleic acid, LIN: linolenic acid, EIC: eicocenic acid, ERU: erucic acid.

In Korea, potentials for raw materials for the production of biodiesel is based on the productivity of rapeseed. And we have to increase rate of arable land utilization as cultivating rapeseed at winter season in order to secure raw materials of biodiesel. In case of double cropping in rice field, rapeseed cultivation brings the yield reduction of rice because the harvesting time of rapeseed falls on the transplanting time of rice. The condition of previous decision could be support scientific approach such as variety improvement, and cultural practice in order to problem solution of the yield reduction of the rice. It is shortening the growth period of rapeseed for early maturity. So we need to develop variety with early maturity.

Crossing method of three ways was profitable to select lines with early maturity. The maturing time of 82015-B-2-2-2 was June 9$^{th}$ and very past among 20 lines. The maturing time of 82009-B-82-1-1 was very late among 20 lines as June 19$^{th}$ (Table 2).

**Table 2. Comparison of agronomic characters of high oleic acid lines.**

| Lines | Flowering times | Maturing times | Plant Height (cm) | No. of siliqua per ear | Silique Length (cm) | Weight of 1,000 seeds(g) |
|---|---|---|---|---|---|---|
| 76152-B-2-4-2-8 | April 24th | June 16th | 160 | 43 | 6.0 | 3.2 |
| 76152-B-2-8-2-2 | April 20th | June 15th | 146 | 46 | 6.8 | 3.6 |
| 76152-B-2-8-3-6 | April 21th | June 15th | 153 | 41 | 7.3 | 3.3 |
| 76152-B-2-8-4-2 | April 18th | June 14th | 140 | 43 | 7.2 | 3.1 |
| 76157-B-4-4-1-7 | April 17th | June 13th | 148 | 46 | 7.0 | 3.6 |
| 76161-B-2-2-2-6 | April 20th | June 14h | 142 | 36 | 7.2 | 3.0 |
| 78113-B-6-3-1-1 | April 18th | June 13h | 131 | 45 | 6.5 | 3.6 |
| 82009-B-101-1-1 | April 22th | June 18th | 158 | 35 | 7.8 | 2.7 |
| 82009-B-108-1-2 | April 25th | June 15th | 161 | 37 | 8.2 | 3.3 |
| 82009-B-108-3-2 | April 25th | June 17th | 160 | 33 | 7.8 | 2.9 |
| 82009-B-111-1-2 | April 25th | June 17th | 158 | 44 | 7.3 | 3.3 |
| 82009-B-111-1-5 | April 22th | June 15th | 148 | 38 | 6.9 | 3.2 |
| 82009-B-77-1-1 | April 23th | June 16th | 167 | 42 | 7.4 | 2.7 |
| 82009-B-82-1-1 | April 23th | June 19th | 160 | 40 | 7.0 | 2.8 |
| 82009-B-89-2-2 | April 18th | June 13th | 166 | 39 | 7.1 | 3.4 |
| 82009-B-96-2-1 | April 18th | June 13th | 163 | 33 | 7.0 | 2.7 |
| 82009-B-98-1-2 | April 20th | June 15th | 162 | 43 | 8.1 | 2.9 |
| 82009-B-99-1-2 | April 17th | June 12th | 151 | 43 | 7.3 | 3.0 |
| 82015-B-2-2-2 | April 12th | June 9th | 165 | 28 | 10.7 | 2.8 |
| YL-MB-60-3-2-3 | April 17th | June 12th | 146 | 43 | 7.2 | 3.2 |

## Discussion

Fatty acid composition of vegetable oil plays an important role to decide its quality. Vegetable oils containing a very high proportion of oleic acid(C 18:1) and correspondingly low proportions of polyunsaturated fatty acids are desirable commodities because they widely used in human and animal diets and in many industrial applications. Especially, the increment of oleic acid content among fatty acid composition of rapeseed oil is in possession of potentials for raw materials for the production of biodiesel.

Development of zero-erucic acid or low glucosinolate variety was one of the major objectives in quality improvement program. So we made use of varieties with good quality of fatty acid composition which was introduced from oversea. It was profitable for improving variety of high oleic acid by three way cross or four way cross.

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