Progress of the Edible-Oil Flax Program at the Crop Development Centre.

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ABSTRACT

An edible-oil flax crop will provide Saskatchewan farmers with an additional cropping option and help to extend crop rotations. Australian researchers have recently produced an edible-oil flax but this genetic material is not available to public institutions. Consequently, we were forced to produce our own mutant flax lines by treating the variety McGregor with the mutagen EMS (ethyl methanesulphonate). The objective of our research was to induce mutations that would lower the linolenic acid content of flax seed. To date we have isolated three mutant lines with lowered linolenic acid levels. Each of these lines has elevated levels of other fatty acids. Line E67 has increased concentrations of palmitic acid, line E1747 greatly increased levels of linoleic acid and line E1929 has increased oleic acid levels.

Flaxseed, as produced today, is processed into linseed oil. The drying properties of linseed oil make it useful as a component of oil-based paints and of linoleum. However, these same drying properties cause linseed oil to oxidize and turn rancid, making it unsuitable for human consumption. The most prevelant fatty acid in linseed oil is linolenic acid and this fatty acid imparts most of the drying quality to the oil.

Green (1986) described the development in flax (*Linum usitatissimum* L.) of a genotype whose seed contained less than 2% linolenic acid. The low linolenic acid character is controlled by two recessive genes that were produced by EMS (ethyl methanesulphonate) mutagenesis in the Australian cultivar Glenelg. These very low levels of linolenic acid have resulted in flax being considered for edible-oil purposes.

The discovery of these fatty acid mutants brought the hope that edible-oil flax cultivars could be developed for Saskatchewan. However, we were unable to obtain low linolenic acid lines from the Australians. We, therefore, began our own mutagenesis program with the hope of duplicating the Australian results.

## Materials and Methods

In May of 1987 20,000 seeds of the cultivar McGregor were treated with a 0.4% solution of EMS after the method of Green and Marshall (1984). This seed was then planted at Kernen Crop Research Farm, University of Saskatchewan. The surviving 7,702 $M_1$ plants were harvested individually in the autumn.

The TBA (thiobarbituric acid) test (Green and Marshall, 1984) was used to identify $M_1$ plants whose seed contained lowered levels of linolenic acid. Ten to fifteen half-seeds distal to the embryo axis from these plants were analyzed singly for their fatty acid content by gas chromatography. The embryo axis half was germinated in a petri dish on an agar-water medium. Half-seeds with reduced linolenic acid levels had the germinated half transplanted to a pot and then grown in a growth chamber at 20°C day, 15°C night with a 16 h day.

Half-seeds from each of these $M_2$ plants were then analyzed on the GC and germinated as before. Once again seeds with reduced linolenic acid levels were grown. This procedure was repeated each generation.

In addition to identifying fatty acid mutations some of this material was examined for other mutations. Twelve hundred $M_2$ lines arising from single $M_1$ plants were evaluated in single rows at the Kernen Crop Research Farm in 1989. Other morphological mutations were also noted in lines selected for lowered linolenic acid.

## Results and Discussion

A germination test of the EMS treated seed showed the germination to be over 80%. The fertility of most of the surviving plants was excellent in marked contrast to the reports of Green and Marshall (1984) and Nichterlein et al. (1988).

To date over 70 lines have been identified by the TBA test as possibly having decreased linolenic acid levels. GC analysis of half-seeds from these lines identified seeds with reduced linolenic acid levels and the corresponding germinating half-seeds were then transplanted to soil in pots and raised to maturity in growth chambers. We are continuing to examine most of these lines but three became of immediate interest and have been studied the most intensively.

The lines E67, E1747 and E1929 have been raised through to the $M_4$ generation and the fatty acid ratios in the $M_5$ seed appears stable. All have reduced levels of linolenic acid (Table 1) with E1747 having less than 2% linolenic acid which is very similar to the level of linolenic acid in the line described by Green (1986). However, unlike Green's material, the mutations, (if indeed there is more than one), were induced in a single $M_1$ seed. But this low linolenic acid level was not seen until seed from the $M_3$ generation was analyzed and not confirmed as being stable until the $M_4$ (Table 2). E67 has palmitic acid levels four times greater than that of McGregor or the other two mutant lines (Table 1). E1929 has oleic and linoleic acid levels double that of McGregor.

Table 1. Fatty acid composition, oleic desaturation ratio (ODR)+ and linoleic denaturation ratio (LDR)+ of the $M_5$ seed of three mutant lines and McGregor.

| Line | Fatty acid | | | | | ODR | LDR |
|---|---|---|---|---|---|---|---|
| | Palmitic | Stearic | Oleic | Linoleic | Linolenic | | |
| E67 | 27.8 | 2.8 | 11.3 | 6.6 | 44.0 | 5.0 | 7.1 |
| E1747 | 7.0 | 3.2 | 15.8 | 71.8 | 1.9 | 5.1 | 0.03 |
| E1929 | 7.1 | 2.7 | 34.7 | 30.1 | 25.2 | 1.8 | 0.9 |
| McGregor | 6.8 | 3.7 | 17.9 | 15.8 | 54.5 | 4.0 | 3.5 |

+ODR = $\frac{\text{\% linoleic + \% linolenic}}{\text{oleic}}$

+LDR = $\frac{\text{\% linolenic}}{\text{\% linoleic}}$

Each of the mutant lines has a different LDR from McGregor with E1747 and E1929 being lower and E67 higher. The ODR of E1929 is quite different from the rest. Thus each of the mutant lines is different from McGregor and from each other.

An additional edible-oilseed crop is required for western Canada as canola production has apparently plateaued and yet much crushing capacity remains underutilized. It is not likely that an edible-oil flax will compete directly with canola as the properties of the oil will be different from canola. Flax is also a traditional crop on the prairies therefore an edible-oil flax will not need to be introduced to producers.

Flax appears to be a more drought-tolerant oilseed than canola and if the drought of the 80s continues then this could be very important. It would help to maintain or possibly increase the cropping diversity we now enjoy in Saskatchewan.

## References

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