Potential alternative oilseeds for south-eastern Australia

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ABSTRACT

The oilseed industry in south-eastern Australia is based almost entirely upon canola, a situation that carries the risks of the breakdown of blackleg resistance or the incidence of other pests and diseases. Additionally, despite the rapid increase in area sown, canola is poorly adapted to drier areas such as the Mallee regions of Victoria and South Australia. Because of these reasons, there is a need to evaluate other oilseeds for suitability to south-eastern Australian farming systems, especially in light of the trend to more intensive cropping and the expansion into high rainfall areas. More crop options will give the changing farming systems greater bio-diversity and lead to enhanced sustainability. Additionally, a diverse range of oilseeds could provide market opportunities for non-food uses such as neutraceuticals or oleochemicals. This paper discusses a preliminary assessment of the agronomic potential some non-traditional oilseeds for production in south-eastern Australia.

KEY WORDS

Alternative oilseeds, industrial oilseeds, diversity, sustainability, agronomy.

INTRODUCTION

Interest has increased in alternative oilseeds due to:

1. The need for more crop options in farming systems that are becoming more intensive.

2. The large increase in the price of fossil-derived fuels, which has focused attention once more on the potential of plant-derived oils for non-food uses. Advances in processing make it feasible to use plant-derived raw materials or oleochemicals to substitute, at least partially, for non-renewable petrochemical feedstocks.

There are two strategies available to obtain new and improved oleochemicals from oil crops (10). Either genes can be transferred into commercial high-yielding crops such as canola, or efforts can be directed to domesticate species that already express these biochemical pathways to make useful novel oils. The first strategy is already in progress and has met with some success, for example high lauric acid canola. However, in addition to the complexities of the introgression of new biochemical pathways into canola, there are also storage and handling problems and food safety issues to deal with. There has also been growing public concern with the adoption and use of these genetically modifying techniques.

Domesticating a new plant species is perceived to be a slow process. Species with desirable fatty acid profiles may be poorly adapted and specialised production systems may need to be developed. However, accelerated improvement of the species may be aided by more recently developed techniques such as the use of molecular markers or double haploids. This would provide our farming systems with new species and add much needed diversity (10).

METHODS

This study involved reviewing current and overseas work on 20 alternative oilseed species that were considered to have agronomic potential in south-eastern Australia and the analysis of a historic data set from field trials undertaken by Salisbury (unpublished data) during the early 1990's. A subset of this data is presented in this paper where approximately 400 lines from the temperate field crops collection were sown in a screening trial at Walpeup in 1991. Data on flowering date, plant vigour, disease susceptibility and fatty acid profile of the oil were collected. These results were validated in additional trials in the Wimmera and Mallee, although the results from all these trials are not presented in this paper. Generally agronomic practices similar for the production of canola were employed.

RESULTS AND DISCUSSION

Preliminary analysis of this data set showed that considerable variation exists in traits of significance to the adaptation of these species, such as flowering date. Figure 1 shows 50% flowering date for lines from 8 species compared to the canola cultivar Eureka. The germplasm evaluated showed significant differences between species, with *Eruca sativa* the earliest flowering, although most species contained lines that flowered as early, or earlier, then Eureka.

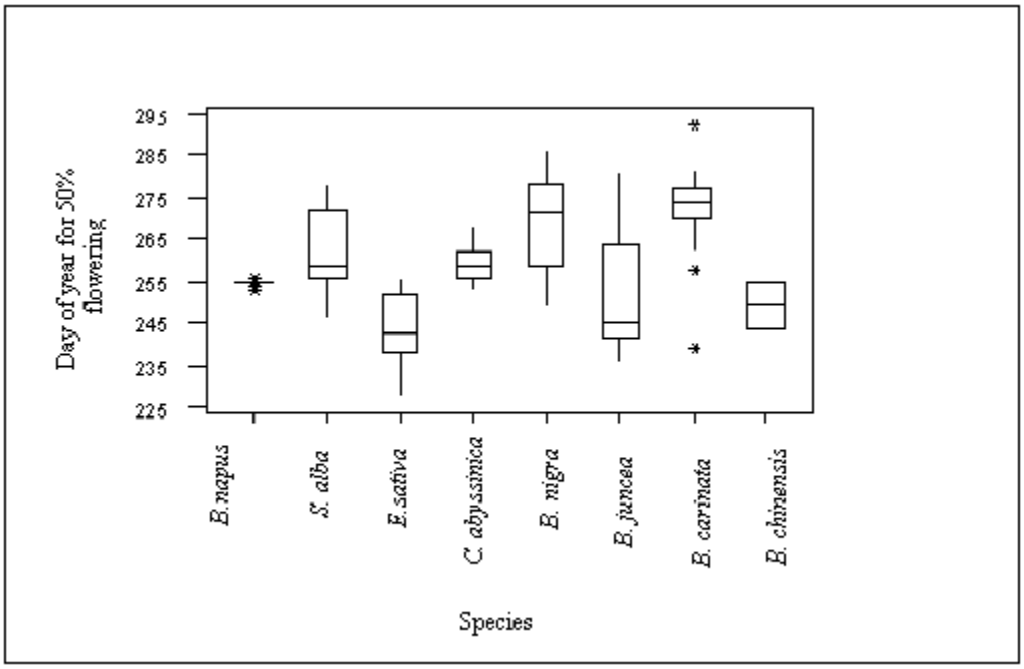

Figure 1: Date (day of year) for 50% flowering of a range of Brassicaceae species at Walpeup in 1991. The box represents the interquartile range, the internal line the median, the lines extending from the box, the minimum and maximum and asterixes represent outliers.

The data in Figure 1 indicates that phenologically, the *Brassica* species are generally suited to winter cropping. Domestication of these crops does carry the risk that they may be susceptible to similar diseases as canola and that they may compete within the same markets. On the other hand, other families provide the opportunities to add biodiversity to cropping rotations, provide oilseed species that may be produced in regions not suitable for canola and pursue oil-products for non-food uses.

The first group of plants was the Brassicaceae. Many of the Brassicaceae are high in erucic acid (C22:1) and therefore, in their natural form, will compete with high erucic acid rapeseed (HEAR) as a source of erucamide for slip agents, plasticisers and lubricants (Table 1). Some of the unexploited species within the Brassicaceae that may have potential in the southern region of Australia include:

Crambe abyssinica- Crambe is a native to the Mediterranean, it is quite drought hardy, and its seed contains 30-40% oil, of which up to 60% is erucic acid (7). It has probably been studied in more detail world wide as a prospective new oilseed crop than other alternative species. Detailed agronomic practices have been developed in North Dakota, USA. The oil has been evaluated successfully for the manufacture of lubricants, plasticisers, nylon and other applications. Although crambe meal contains unacceptably high levels of glucosinolates, it has been shown that proper conditions during seed processing make the meal useful for beef cattle feeding. Crambe production has been commercialised in North Dakota where it was introduced in the 1940's and now has an annual production area of 16,000 ha. It is estimated that North Dakota supplies 20% of the world demand for erucic acid (14).

Table 1. Fatty acid composition of oilseeds high in erucic acid.

	Oil	Fatty acids								
Species	(%)	C18:0	C18:1	C18:2	C18:3	C20:1	C22:1	C22:2	C24:1	Others
Crambe abyssinica[1]	30 - 45[5]	0.9	15.9	8.7	8.7		56.4			9.4
HEAR[2]	40 – 45	2.3	12.0	11.2	12.5	8.0	49.5	-	1.1	3.4
Brassica juncea[3]	37-44	1.1	11.5	17.7	10.2	6.8	47.0	1.3		4.4
Brassica carinata[3]		1.2	10.0	18.3	13.0	8.2	41.6			7.7
Sinapis alba	30-37[5]									
cv. Gisilba[4]		1.2	31.6	9.5	8.2	11.8	35.1			2.6
cv. Mustang[4]		0.8	18.4	11.1	9.3	4.6	53.4			2.4
Low erucic[4]		1.9	66.2	10.6	11.6	4.1	2.9			2.7

[1] (7), [2] (1), [3] R. N. Oram (unpub.) [4] (2) and [5] (6)

Sinapis alba- White mustard is the only crop species in the small genus of Sinapis, and is related to the weed charlock (*S. arvensis*). White mustard is commercially grown in Sweden as an oil crop and in Canada as a condiment, providing the 'hot' flavour (13). Breeding programs for white mustard have been undertaken in Canada, Sweden, Germany, the UK and Australia. In Sweden, recent breeding activity has been toward white mustard with higher erucic acid contents (13).

Brassica nigra- Black mustard probably originated in the Asia Minor-Iran regions where it was commonly used as a commercial spice. Through seed trade, it became widespread in Europe, Africa, Asia, India and the Far East. Early forms are short-season with a spreading, semi-erect growth habit up to 1m tall. Black mustard was abandoned in favour of the more suitable *B. juncea* (Brown mustard) because Black mustard is dehiscent and requires hand harvesting whereas Brown mustard can be mechanically harvested (13).

Brassica carinata- Ethiopian mustard, is relatively slow growing and has a very limited distribution in north-east Africa, but is an important vegetable and oilseed in the central highlands of Ethiopia at altitudes between 2,200 and 2,800 m (12. Ethiopian mustard has larger, paler flowers, larger yellow or brown seeds, and more basal branches than *B. napus*. The original form is high in glucosinolates and has about 42% erucic acid in its oil. *B. carinata* is cultivated only in Ethiopia, where traditional farmers have

developed vegetable and oilseed cultivars. A considerable research effort is now being invested in the species to produce a new oilseed crop for dry regions of Canada (4), Spain (5) and India (8).

Non-brassica oilseed species, which may have potential within south-eastern Australia, include the following:

Limnanthes alba - Meadowfoam is a member of the Limnanthaceae and it is native to southern Oregon and northern California. It is a winter annual and enjoys wet conditions. The oil is unique as it contains more than 90% long chain monounsaturated fatty acids, more than any other known oil. The oil is highly stable, even at high temperatures and pressures, making it an ideal industrial oil for lubricating purposes. Meadowfoam has been grown by Agriculture Victoria (PVI, Hamilton) in the higher rainfall areas of Victoria.

Calendula officianalis- Marigold is a native to the Mediterranean, a member of the Asteraceae family and thrives best in open, sunny situations on light, easily warmed soils. The seed has an oil content of around 20% of which about 60% is calendic acid (9). This acid could have applications in the manufacture of paints and coatings, cosmetics and some industrial nylon products having similar properties to tung oil (11).

Euphorbia lagascae, Vernonia galamensis, Stokesia laevis- These three species have potential as epoxy acids for the production of plastics, paints lubricants and as baked coatings on steel. *E. lagascae* is a member of the Euphorbiaceae and native to Spain. Its seeds have up to 50% oil of which 60% is vernolic acid. Research on *E. lagascae* has been underway at the USDA- National Centre for Agricultural Utilisation Research. One line has been grown in southern Australia (3). *V. galamensis* and *S.laevis* both belong to the Asteraceae family. *V. galamensis* is distributed in several African countries and exhibits better seed retention than other species in the genus. Germplasm development work is underway at the U.S. Water Conservation Laboratory, Phoenix, Arizona. Little is known about the agronomy of these species and neither has been trialed in south-eastern Australia.

CONCLUSION

Most new alternative oilseeds are undomesticated species and therefore exhibit many characteristics of wild plants, for example seed shattering, non-uniform ripening and low oil yields. However, within the germplasm available, there is significant variation, for features of agronomic significance that suggests the possibility of successful domestication of these species. There is also a range of oil types within the species that have industrial potential. The future development of these crops to produce industrial feedstocks will require a multi-discipline approach involving partnerships between research, production and manufacturing sectors.

AKNOWLEDGEMENTS

This project is funded by the GRDC (Project No. UM140)

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