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as Alternative Crops in U.S. Agriculture: Can They Compete?

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Farmers continue to search for alternative crops to include in traditional crop rotations as a means of increasing farm income and reducing risk exposure. With reductions in support offered by the U.S. farm program, this search will only acquire greater importance. Alternative crops can increase farm income and reduce risk exposure by allowing more efficient utilization and distribution of farm resources, breaking disease, pest and weed cycles, providing access to growing markets, and offering environmental benefits such as reduced soil erosion and improved soil tilth.

Rapeseed (*Brassica napus L.* and *B. rapa L*) and crambe (*Crambe abyssinica L*), members of the Brassicacae family, have generated considerable interest as potential alternative crops in many regions of the United States. Rapeseed and crambe are oilseed crops, with oil and meal obtained as primary and secondary products. Two types of rapeseed are produced commercially: high erucic acid (HEA) and low erucic acid (LEA). Crambe is also an HEA oilseed crop. HEA oil is largely confined to industrial uses, such as specialized lubricants, coatings, and slip agents. High levels of erucic acid may be toxic to humans and, therefore, impose limitations on oil use for food. For this reason HEA does not compete with other vegetable oils in European and American food markets. Current industrial standards dictate a minimum 45 percent erucic acid content for HEA oils. Crambe meal and meal from a few older cultivars of rapeseed usually contain high levels of glucosinolates, which pose digestive and palatability problems for livestock, limiting their use as a protein supplement in livestock rations (USDA-ERS 1/97). Most HEA rapeseed varieties now have low glucosinolate levels, producing seed meal of canola quality, which is an excellent protein source for livestock rations.

Originally developed by Canadian researchers in the 1970's, LEA or edible rapeseed (canola) contains a maximum of 2 percent erucic acid and low levels of glucosinolates, and has been certified as safe for human consumption by the U.S. Food and Drug Administration. Canadian researchers coined the term "canola" to denote rapeseed cultivars low in both erucic acid and glucosinolate content. LEA oils compete in the edible oils market against soy, corn, cottonseed, and palm oils. The glucosinolate content in the seeds of modern LEA and HEA rapeseed cultivars is sufficiently low that the meal can be safely used as a protein supplement in livestock rations. Crambe meal, being higher in glucosinolates, is less valuable as a livestock feed.

The HEA and LEA oils have different characteristics and they do not necessarily compete with each other in the oils market. The HEA oils compete in the industrial market against imported

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HEA oils and with petroleum based products. Domestic HEA oils would replace imports if they could be produced and sold at competitive prices. HEA seed meal from crambe is not suitable for single-stomach animals, such as swine and poultry and can be fed to cattle in limited quantities. Crambe oil is a high erucic acid, and competes in the same markets as industrial rapeseed oil.

The canola market, however, exhibits considerable growth potential. Canola oil is relatively price competitive with other vegetable oils. The seed meal is high in protein and is an excellent livestock feed. Furthermore, canola oil has the lowest saturated fat content of the major vegetable oils, broadening its appeal to increasingly health conscious consumers (Allelix Crop Technologies, Ltd., 1989). Canola oil consumption in the United States increased almost 500 percent between 1987 and 1994, most of which was imported. The continuing growth in U.S. canola consumption, coupled with the low market share of domestic canola producers, provides evidence of significant growth opportunities for cost efficient U.S. producers.

The overall objective of this study is to assess the economic viability of rapeseed, including canola and crambe, as alternative crops in various regions of the United States. Specific objectives are to:

1. Examine the characteristics of the markets;
2. Evaluate the costs and returns of production; and
3. Determine economic conditions under which rapeseed or crambe, become viable alternative crops to include in crop rotations.

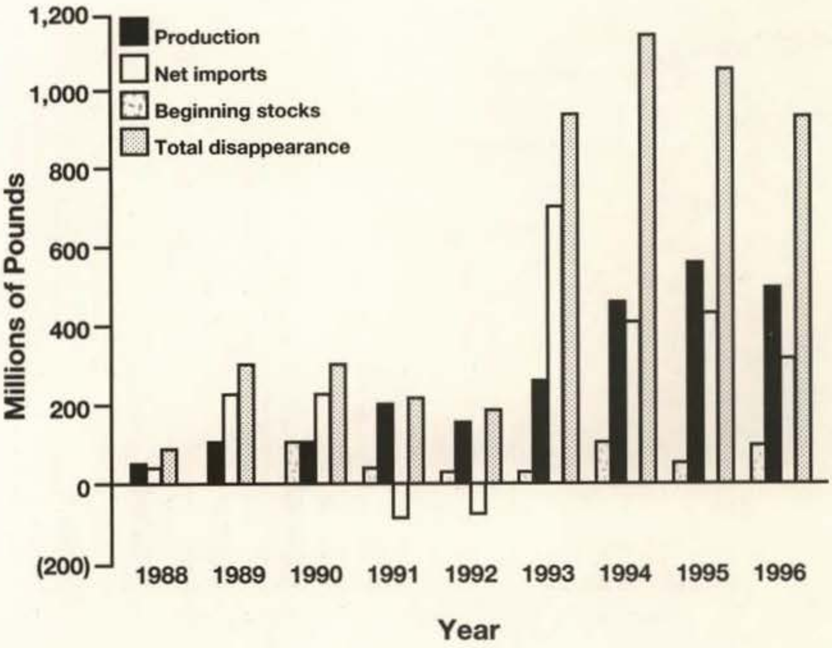
In Section 2, the characteristics of the oilseeds market are discussed. In Section 3, the costs and returns of incorporating rapeseed (including canola) and crambe into farm production are examined. In Section 4, the economic conditions under which these erucic acid oilseeds would enter rotation patterns are evaluated, and a summary and conclusions are provided in Section 5.

Characteristics of the erucic acid oilseeds markets

A limited acreage of HEA rapeseed has been grown in the United States for many years, primarily in the Palouse region of Northern Idaho (Carlson, et al., 1996). This acreage has not increased appreciably over time. In fact, total U.S. harvested acreage of HEA rapeseed decreased from 19,400 acres in 1988 to 2,400 acres in 1995 (USDA-ERS, 12/96). Crambe acreage, primarily in North Dakota, reached a high of nearly 58,000 acres in 1993. Only negligible amounts of crambe were grown (for seed) in North Dakota in 1995 because most of the oil from the 1994 crop had not been sold prior to spring planting. However, with the entry into the market of a new buyer, contracted acreage of crambe was estimated at 22,000 acres in 1996 (USDA-ERS, 1/97).

Much of the U.S.supply of HEA (industrial) oil comes from imports. Industry sources estimate imports of industrial rapeseed oil average 25 to 30 million pounds annually, primarily from Canada and Europe (USDA-ERS, 12/96). Erucimide is the largest market for HEA oils. It is used on plastic wrappers, bags, and other plastic film products to keep them from clinging together (Leonard, 1994). Other uses include paints, coatings, nylon, cutting oil, cosmetics, marine oil, emolliants, erucyl alcohol, befenyl alcohol, lubricants, food emulsifiers and photography (Leonard, 1994). While significant technology now exists for many industrial applications of HEA oils, the cost must become more competitive for substantial growth to be realized. Until that point, HEA oils will compete in niche markets. Even so, imports continue to be the main source of supply of high erucic acid oils in the U.S. (USDA-ERS 1/97)

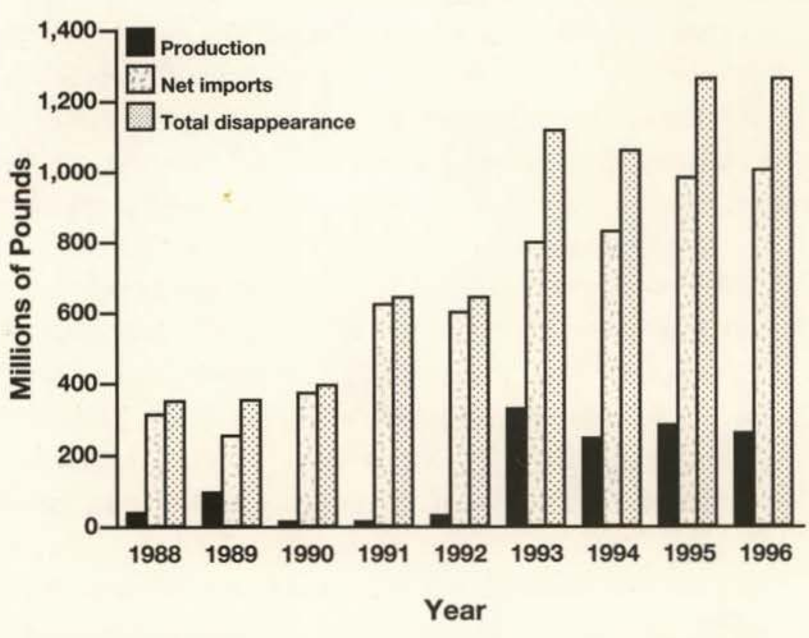
Figure 1. U.S. canola seed supply and disappearance, 1988–1996.



Source: USDA, ERS Oil Crops Yearbook. Oil Crops S&O/OCS, October, 1996.

The canola market has experienced substantial growth since its inception. Canada now produces more than eight million acres annually, grown primarily in the prairie provinces. (ISTA Mielke GmbH, 1994) Canola has also become Canada's second largest export crop, exceeded only by wheat. U.S. production of canola has also increased dramatically since the Food and Drug Administration certified LEA rapeseed oil (canola) to be safe for human consumption in 1985. In 1982, U.S. canola acreage was estimated at about 6,400 acres (USDA-ERS, 10/91). By 1995 U.S. canola acreage had increased to a high of 445,000 acres, followed in 1996 by an estimated 397,000 acres planted. Similarly, U.S. consumption of canola oil increased from 486 million pounds in 1988 to an estimated 1,246 million pounds in 1996. Yet, since 1988, U.S. canola oil production has averaged less than 30 percent of domestic consumption, the remainder imported primarily from Canada (USDA - ERS, 10/ 1996). Hence, there is ample room for increased domestic production, if U.S. producers can compete with canola from Canada. Production, imports, and total disappearance of U.S. canola seed are shown in Figure 1. Similar numbers for canola oil and canola meal are shown in Figures 2 and 3. As noted, some imports are in the

Figure 2. U.S. canola oil supply, 1988–1996.



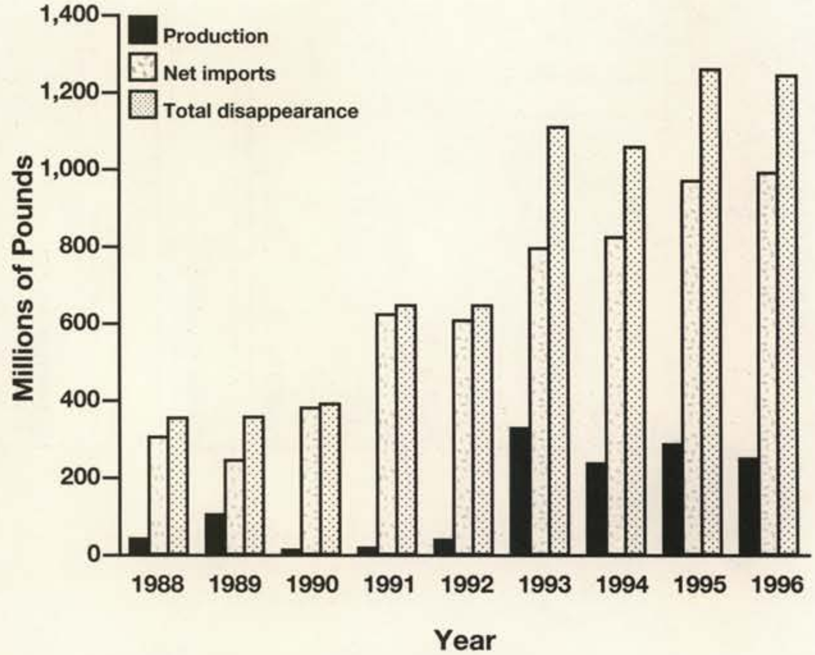
Source: USDA, ERS Oil Crops Yearbook. Oil Crops S&O/OCS, October, 1996.

form of seed and some as oil. Meal may also be traded as a separate product.

Demand and markets

In terms of world oilseed production, canola now ranks third behind soybeans and cottonseed. In world oilseed trade, however, canola is ranked second behind soybeans (Ag Outlook, 8/92). Further, rapeseed has exhibited the fastest growth rate among oilseeds over the past decade (8.2 percent). While this figure also includes (HEA) rapeseed, much of this growth can be attributed to canola. Canada is the largest producer and exporter of canola in the world. France and Germany are also major producers and exporters of canola. India and China produce substantial quantities of rapeseed, but are currently net importers. However, each appears to be pursuing a self-sufficiency objective with respect to rapeseed, which may limit future export opportunities to these countries.

Figure 3. U.S. canola meal supply and disappearance, 1988–1996.



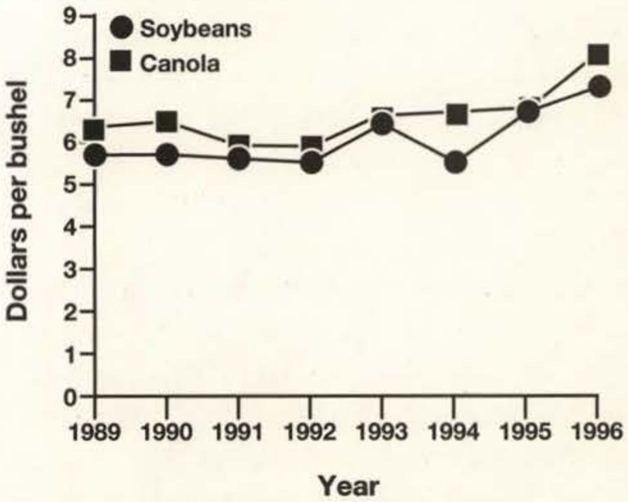
Source: USDA, ERS Oil Crops Yearbook. Oil Crops S&O/OCS, October, 1996.

Japan is the largest importer of canola. Given its limited land base, Japan will continue to be a large importer of canola in the future. Much of Japan's canola imports are currently sourced from Canada. Even so, Japan remains flexible regarding supply sources, allowing an opportunity for American canola producers to participate in the Japanese market. Two caveats must be noted, however. First, Japanese ports are structured to handle bulk shipments of canola as opposed to container shipments. Thus, a canola production base large enough to enable bulk shipments will likely be required to make inroads into the Japanese market. Second, Japanese importers prefer to import canola seed and thereby reap the value-added benefits of processing the raw product. Hence, substantial canola seed exports to Japan would detract from the minimal level of production needed to support a dedicated canola processing plant in the Pacific Northwest (PNW).

In areas where soybeans or sunflowers are grown, significant capacity in oilseed crushing facilities exist. With a few modifications, rapeseed or crambe could be processed in existing facilities. As a result, north central, Midwest and southern canola producers have processing outlets for their canola production, while there are no such facilities in the PNW. However, the PNW has better access to the Japanese market for whole seed than other areas because of easy access to West Coast ports.

An important factor, which will affect the growth potential of the erucic acid oilseeds, is its relationship to competing oils. The price of oilseeds is determined by the value of the oil and meal obtained through processing. Given this, erucic acid oilseeds must compete in both the oil

Figure 4. Price per bushel of U.S. soybeans and canola, 1989–1996.



Source: 1998 Soya Yearbook Plus, Soyatech Inc., Bar Harbor, MI.

and meal markets. HEA oils are relatively expensive when compared with petroleum-based industrial oils, despite being superior for some uses. Crambe seed meal value has typically been heavily discounted because of potential toxicity in some animals. Crambe meal is said to sell for about one-third of the value of soymeal (Glaser, 1966). HEA rapeseed meal that is low in glucosinolates would have a value equal to canola seed meal.

The situation is quite different in the canola market, however, because canola oil and meal are non-toxic and compete with other vegetable oils and meals in their respective markets. Soy oil dominates the vegetable oil market and heavily influences vegetable oil prices. Canola oil prices must be competitive with soy and other vegetable oils except for small amounts in health food niche markets. On the meal side, soy meal is the dominant product. Soybean crush is often dictated by meal demand as the meal often brings a greater return than the oil. Processing however, may be delayed if supplies of oil become burdensome (ISTA Mielke GmbH, 1994).

Canola meal has about 75 percent of the protein value of soy meal; thus, canola meal is sold at a discount relative to soy meal in order to remain competitive in the meal market. In the Portland, Oregon, market, canola meal usually sells for 70 percent to 75 percent of the soy meal price (Noordam and Withers, 1996). These factors suggest that canola prices are inexorably linked to those of competing oilseeds, particularly soybeans. Recent research has corroborated this hypothesis, finding that canola prices have closely tracked U.S. soybean prices. (Figure 4 shows this relationship.) As a result, it is unlikely that substantially higher canola seed prices will be available to "jump start" increased domestic production, as happened with soybeans in the 1950's and 60's. On the other hand, canola's higher oil content results in more oil and less meal per ton of seed than soybeans when processed.

Environmental adaptability

Environmental adaptability is another factor, which will affect the adoption of erucic acid oilseeds as alternative crops on U.S. farms. Rapeseed can be seeded as either a winter crop or as a spring crop in areas where winter crops are feasible, increasing producer flexibility. Crambe is primarily a spring crop. Rapeseed and crambe can permit more efficient use of farm resources since they can be produced using existing equipment on most farms, and hence, do not require significant new investments by producers. In the past, winter rapeseed had to be preceded by fallow in dry regions, such as the inland empire of the PNW. However, this is changing with the development of new cultivars. In the eastern half of the northern tier states and in southeastern states, moisture is not as much of a problem. Spring rapeseed yields typically average 50 to 75 percent of winter rapeseed yields in the Pacific Northwest because of the shorter growing season and lower moisture availability. The warmer winter in the southeast makes it possible for spring rape to be grown during winter months.

Rapeseed and crambe may out perform other spring crops in years of limited moisture because of their deep tap-roots. However, rapeseed and crambe are susceptible to numerous pests for which there are currently few chemicals labeled for use in the United States. Also, rapeseed and crambe acreage must be limited in rotations to control disease problems that reduce yields if grown too frequently. Another possible limiting factor is that rapeseed and crambe do not tolerate poorly drained soils very well, which could pose a problem in regions of high rainfall.

Costs and returns of rapeseed and crambe production

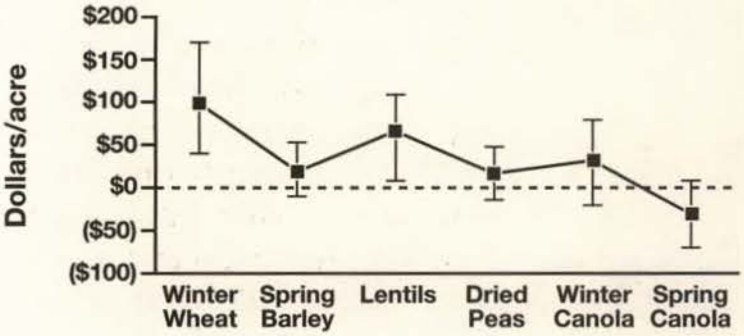
Four areas of production were chosen to assess the economic viability of growing rapeseed and crambe as alternative crops in existing rotation patterns: Northern Idaho, North Dakota, Iowa, and Georgia. These four states are among those showing the greatest interest in erucic acid oilseeds. Minnesota, Missouri, Illinois, Montana, and others also have had or now have some acreage of canola. While industrial rapeseed originally received the most attention, the focus has shifted to edible (LEA) varieties. Most crambe has been grown in North Dakota while canola is more widely grown throughout the United States. Both rapeseed and crambe were considered as potential alternative crops for North Dakota and Iowa while HEA and LEA rapeseed were included for Idaho and Georgia.

This analysis does not consider the historical influence of the U.S. farm program on the adoption of rapeseed and crambe. The farm program has been dramatically scaled back under the most recent Agricultural Act. Under "Freedom to Farm," farmers can produce whatever crops they choose and are not limited by set-aside acres or acreage bases. Producers will no longer be able to take advantage of incentive programs, such as the minor oilseeds provisions that were included in previous farm programs. This will increase the need for alternative crops to be economically feasible. The long term success of rapeseed and crambe will depend entirely on their ability to compete with traditional crops in a relatively free market. Under the old farm bill there was some incentive to seed oil crops on set aside acres.

Data on costs of production and yields for rapeseed and crambe are limited in some areas and their reliability has not been proven because of their relative "newness." Cost of production data for rapeseed, crambe, and traditional crops in each region were obtained from Experiment Station and Extension Service estimates. Spring HEA and LEA rapeseeds employ essentially identical production practices; hence, the same cost-of production data is used for both. Winter crop costs are slightly higher. Yield data were obtained from various sources. For Idaho, yield data were obtained from the Idaho Agricultural Statistics Service. For Georgia, average yields were obtained from Extension Service estimates. For North Dakota and Iowa, yield data were obtained from yield trials and from reported farm production yields. Where possible, price data were obtained from the USDA/NASS state agricultural statistics services. However, in the cases of rapeseed and crambe, price and yield data are not released on a state by state basis. Therefore, average price and yield estimates were obtained from Experiment Station personnel, county Extension agents, rapeseed-marketing organizations, and (in Idaho) from rapeseed producers.

Traditional crops and crop rotations were determined for each study area. The existing rotations were then rearranged to include rapeseed (or crambe) in addition to or in place of the typically lowest valued crop. Using GAMS (General Algebraic Modeling System) methodology

Figure 5. Net returns by crop: northern Idaho, 1988–1995.

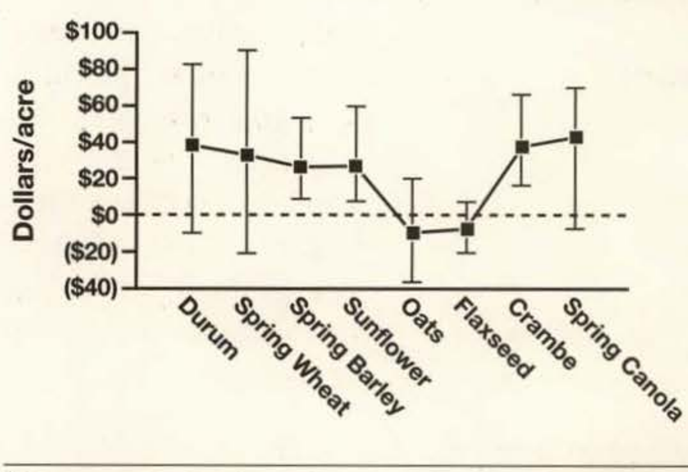


with price and yield data for 1988 through 1995, net returns per acre were calculated for each crop and for each rotation[1]. Using the given cost of production, price, and yield data for rapeseed, crambe, and traditional crops, optimal rotations were determined for each region. In order to identify the economic conditions under which rapeseed and crambe would enter the optimal rotation in each region, prices and yields were then varied. If rapeseed or crambe do not replace another crop in the rotation at prices and yields now obtained, or do not increase income by being included, then at what price or yield would they enter the rotation? Even though the analyses in this paper specified the four states-Iowa, Georgia, North Dakota, and Idaho-they were thought to be somewhat representative of regions in the U. S. that are similar in terms of climate and cropping practices.

Northern Idaho

The GAMS model was used to calculate the range of net returns per acre for each crop typically grown in northern Idaho for the period 1988 to 1995. Under typical cropping conditions for the period, winter wheat was the most important and highest paying crop. For typical crops grown in Northern Idaho, net returns per acre were highest for winter wheat, followed by net returns per acre for lentils and for winter canola (Figure 5). Traditional rotations in the region are two-year wheat-pea (lentil) rotations or three-year wheat-barley-pea (lentil) rotations. Because winter canola provided higher average net returns per acre than either peas or barley under typical circumstances, it would be expected that winter canola would find a place in typical rotation patterns in northern Idaho, especially where fallow is practiced. Only a small portion of cropland in northern Idaho is currently fallowed which limits winter canola and winter rapeseed (HEA) acreage. Fallow was more common under the old farm bill with set aside acres.

Figure 6. Net returns by crop: North Dakota, 1988–1995.

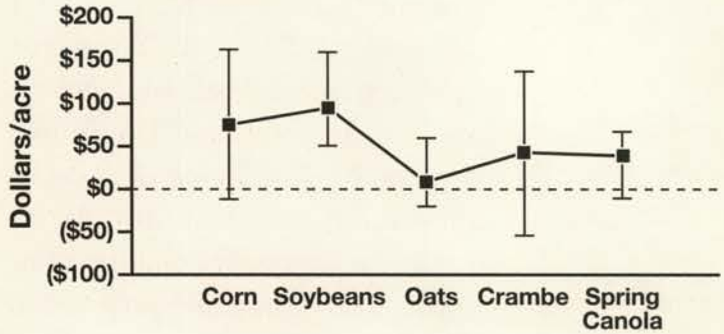


North Dakota

The north central region of North Dakota is known as a dryland grain-producing region. Wheat (both durum and other spring varieties) is generally the most important and highest paying of crops in

[1] Net returns used in this study are defined as gross returns per acre (yield per acre x price per unit of crop) minus cash variable and cash fixed costs of production per acre.

Figure 7. Net returns by crop: Iowa dryland, 1988–1995.



the area. Indeed, for the period 1988 to 1995, the GAMS model indicated that durum wheat generated the highest net returns per acre and hard red spring wheat resulted in the third highest net returns per acre of the crops studied. Spring-planted rapeseed (canola) contributed the second highest net returns per acre, according to 1988 to 1995 data (Figure 6). Net returns per acre for crambe, another HEA oilseed crop, were also comparable to net returns per acre for durum and hard red spring wheat over the period. Traditional rotations in the region usually consist of planting of one or both durum and hard red spring wheat, some other type of grain crop, and an oilseed crop. Based on 1988 to 1995 price and yield data, spring planted canola and crambe both provided much greater net returns per acre than did either oats or flaxseed, and slightly greater returns than sunflowers and barley. Canola and crambe could therefore be expected to find a place in typical rotations in the grain belt of northern North Dakota.

Iowa

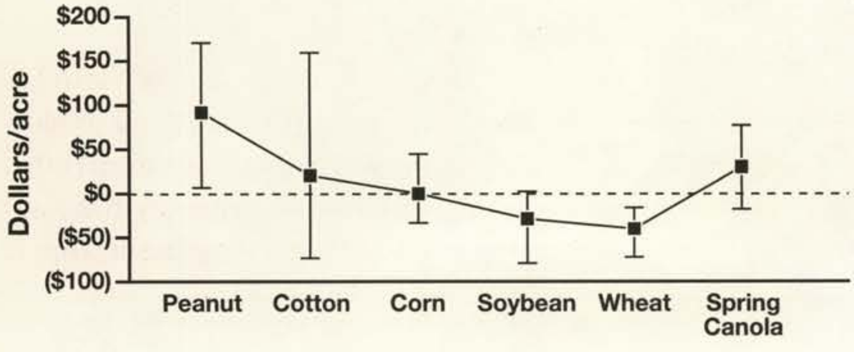
Corn and soybeans are the major crops grown in Iowa and are usually alternated in two-year rotations. In some cases, oats are planted in the rotation to break pest cycles in the more lucrative corn and soybean crops. Based on 1988 to 1995 prices and yields for crambe and spring canola, these crops could not compete with corn or soybeans in typical rotations (Figure 7).

However, both crambe and spring canola contributed greater net returns per acre than oats and therefore, could be expected to find a place in corn-soybean-oat rotations.

Georgia

The major crops grown in the dryland portion of Georgia are peanuts and upland cotton. These crops are often grown in rotation with corn, soybeans, and wheat. However, yield and price data for 1988 to 1995 indicates that spring canola contributes greater net returns per acre than all three of these alternative crops (Figure 8). This indicates that spring canola could be expected to find a place in typical cropping patterns in the Georgia dryland area, profitably replacing corn, soybeans, or wheat in the rotation.

Figure 8. Net returns by crop: Georgia dryland, 1988–1995.



Under what conditions would erucic acid oilseeds enter typical rotations?

Typical rotations for each growing area of the four states were entered into the GAMS model, using 1988 to 1995 prices and yields for each crop. It was assumed that farmers in each area would continue planting crops in rotations that had historically proved to be the most profitable over time. Rapeseed (canola) and crambe would only be included in the rotation if the expected net returns were greater than the net returns of the rotation without canola or crambe. The GAMS model was used to determine the net returns for these rotations, with and without canola or crambe, at 1988 to 1995 prices and yields for each area. Then the prices and/or yields for canola and crambe were adjusted to determine at what price and/or yield rapeseed (canola) or crambe would profitably enter the rotations and enhance the net returns per acre. As the analysis was made using enterprise data, rotational effects on productivity were not fully considered in the evaluation.

Northern Idaho

In the northern Idaho dryland grain region, the most common rotations are a two-year wheat-dried pea (or lentil) rotation or a three-year wheat-barley-dried pea (or lentil) rotation. Using 1988 to 1995 data, the net returns per acre were determined for the typical rotations, with and without the inclusion of either spring or winter canola. It was assumed for this study, that 50 percent of the available land was planted in winter wheat in any given year. The average net returns for each rotation are listed and ranked from high to low in Table 1.

Table 1: Net returns per acre by rotation: northern Idaho, 1988 to 1995.

	WL	WBL	WLFC	WBLFC	WLS	WBLS	WP	WBP	WPFC	WBPFC	WBPS	WPS
1988	$116.77	$102.02	$94.94	$93.02	$84.77	$85.61	$92.71	$89.99	$86.92	$87.01	$77.59	$72.74
1989	$119.51	$103.94	$97.85	$95.48	$93.06	$91.50	$92.49	$90.43	$88.85	$88.73	$82.49	$79.55
1990	$38.42	$34.55	$36.93	$35.37	$33.81	$32.77	$35.20	$32.94	$35.86	$34.56	$31.70	$32.20
1991	$68.87	$53.09	$50.75	$47.39	$54.53	$48.79	$32.37	$34.84	$38.58	$38.26	$36.62	$36.28
1992	$59.43	$38.15	$32.45	$28.56	$28.50	$24.62	$15.41	$16.14	$17.78	$17.55	$9.95	$6.45
1993	$82.87	$62.84	$42.70	$42.73	$43.74	$43.43	$21.15	$31.98	$22.13	$27.30	$22.86	$12.88
1994	$46.05	$41.28	$56.26	$51.32	$26.12	$29.58	$64.23	$50.37	$62.32	$55.86	$35.64	$35.21
1995	$122.97	$117.13	$108.39	$109.11	$99.89	$103.68	$105.33	$108.30	$102.51	$104.70	$97.80	$91.06
Avg.	$81.86	$69.13	$65.03	$62.87	$58.05	$57.50	$57.36	$56.87	$56.87	$56.75	$49.33	45.80
Rank	1	2	3	4	5	6	7	8	9	10	11	12
Range	84.6	82.6	75.9	80.6	73.8	79.1	89.9	92.2	84.7	87.2	87.9	84.6
Std Dev	34.2	33.4	30.4	31.2	30.2	31.2	35.9	34.3	32.8	32.7	32.0	31.5

Key to rotations:

WL = Winter Wheat–Lentil **WBL** = Winter Wheat–Spring Barley–Lentil **WLFC** = Winter Wheat–Lentil–Summer Fallow–Winter Canola

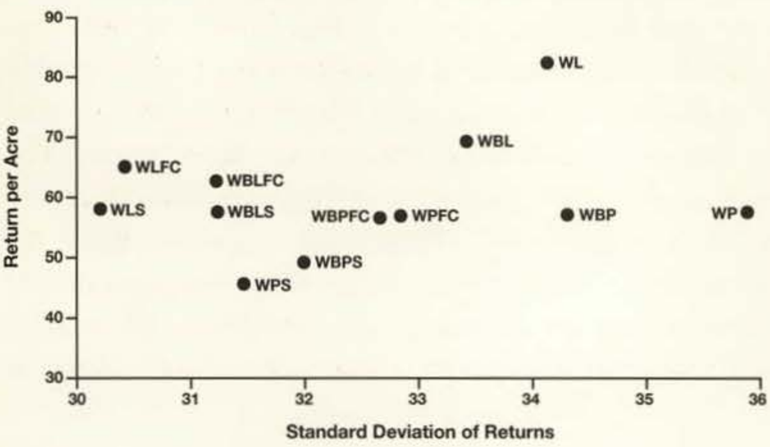
WBLFC = Winter Wheat–Spring Barley–Lentil-Summer Fallow-Winter Canola **WLS** = Winter Wheat–Lentil–Spring Canola

WBLS = Winter Wheat–Spring Barley–Lentil–Spring Canola **WP** = Winter Wheat–Dried Pea **WBP** = Winter Wheat–Spring Barley–Dried Pea

WPFC = Winter Wheat–Dried Pea–Summer Fallow–Winter Canola **WBPFC** = Winter Wheat–Spring Barley–Dried Pea-Summer Fallow–Winter Canola

WBPS = Winter Wheat–Spring Barley–Dried Pea–Spring Canola **WPS** = Winter Wheat–Dried Pea–Spring Canola

Figure 9. Northern Idaho Alternative Rotations, 1988–1995.



Although it would appear that average net returns per acre were distinctly dissimilar for the different rotations, analysis of the variance in net returns within and between rotations indicated that those differences were not statistically significant[2]. The variability of net returns was so great between years (because of yield and price fluctuations for all crops) that no significant differences in net returns per acre could be identified between rotations. As winter wheat is the major crop in the area and usually the most profitable, the acreage is limited by rotational constraints and in the past, by government acreage restrictions. The above rotations all included 50 percent winter wheat, in rotation with the other crops. This would make the average net returns per acre highly dependent upon the net returns for winter wheat and the variability of net returns per rotation over time would also be highly correlated to the variability of net returns per acre for winter wheat.

Comparisons using the t test again indicated no significant differences at the 95 percent level except for the WPS rotation. Figure 9 compares the mean return with standard deviations (s.d.). This shows that while WL had the highest returns it also had a higher s.d. Returns were lower for WLS but the s.d. was also lower, meaning less risk but lower average net return. The producer must choose between the possibility of greater income while bearing greater risk with that of lower risk and lower income. The choice may be influenced by the producer's attitude toward risk and the financial strength of the business. As differences between standard deviations were not large, a farm operator would probably put more weight on rotations bringing highest net returns. Winter canola was included in the rotations ranked third and fourth. Spring canola came in at the sixth-ranked rotation. Peas ranked slightly better than spring canola.

At 1988 to 1995 average yields and prices, rotations with neither spring, nor winter canola generated higher net returns per acre than the same rotations including canola (Table 1). Including spring or winter canola in typical wheat-lentil (or pea) and wheat-barley-lentil (or pea) rotations reduced net returns per acre. Although these reductions in net returns may not be statistically significant because of the year to year variation in net returns per acre (based on data used for this study), they indicate neither an economic advantage nor distinct disadvantage of including canola in the rotation.

During the eight-year period, the price for low Erucic acid (LEA) rapeseed (canola) in Idaho fluctuated between \$9.72/cwt. and \$11.10/cwt. (average \$10.46/cwt.). Over this same period, average yields for winter canola ranged between 14.7 cwt. and 22.7 cwt. (average 19.1 cwt.) Per acre and yields for spring planted canola ranged from 9.3 cwt. to 17.5 cwt. (average 13.7 cwt.) per

[2] Analysis of variance of the raw data resulted in an F-value of 0.66. Analysis of variance of ranked data resulted in an F-value of 0.89.

acre. However, winter canola was preceded by fallow, which increased the per acre cost of winter over spring canola. Fallow costs were included in the winter canola enterprise.

Using the GAMS model, it was determined that, at average 1988 to 1995 yields for winter and spring canola (19.1 cwt./acre and 13.7 cwt./acre, respectively), the price of canola would have to increase to between $10.60/cwt. and $17.73/cwt. (average price $13.56/cwt.) for a rotation including canola to provide greater net returns per acre than typical rotations without canola. Table 2 lists the various prices (per cwt.) at which the different rotations with canola generate higher net returns per acre than the typical rotations without canola. The prices in the left column are the minimum prices per cwt. at which the average net returns per acre for the rotation including canola exceed the average net returns per acre for the specified rotation without canola. For example, with canola price at $10.60 the WPFC rotation surpassed the WBP rotation.

Table 2: Prices that would be needed to bring canola into typical northern Idaho rotations, at typical average yields.

Suggested price ($/cwt.)	Winter canola (Avg. Yield 19.1 cwt.)	Spring canola (Avg. Yield 13.7 cwt.)
@$10.60/cwt.	WPFC > WBP	
@$10.73/cwt.	WBPFC > WBP	
@$10.99/cwt.	WPFC > WP	
@$11.91/cwt.	WLFC > WBL	
@$13.35/cwt.	WBLFC > WBL	
@$13.72/cwt.		WLS > WBL
		WPS > WBP
@$13.91/cwt.		WBPS > WBP
@$14.09/cwt.		WPS > WP
@$15.73/cwt.		WBLS > WBL
@$16.23/cwt.	WLFC > WL	
@$17.73/cwt.		WLS > WL

Table 3: Yields that would be needed to bring canola into typical northern Idaho rotations, at typical average prices.

Suggested yield (cwt./acre)	Winter canola (Avg. $10.46/cwt.)	Spring canola (Avg. $10.46/cwt.)
@17.95 cwt. /acre		WPS > WBP
		WLS > WBL
@18.21 cwt./acre		WBPS > WBP
@18.45 cwt./acre		WPS > WP
@19.60 cwt./acre	WBPFC > WBP	
	WPFC > WBP	
@20.07 cwt./acre	WPFC > WP	
@20.60 cwt./acre		WBLS > WBL
@21.74 cwt./acre	WLFC > WBL	
@23.23 cwt. /acre		WLS > WL
@24.37 cwt./acre	WBLFC > WBL	
@29.62 cwt./acre	WLFC > WL	

It was also determined that, at the 1988 to 1995 average price for canola ($10.46/cwt.), yields for spring canola would have to increase to between 17.95 cwt./acre and 23.23 cwt./acre for rotations including spring canola to generate higher average net returns per acre than typical rotations without canola. At the average price of $10.46/cwt., yields for winter canola would have to be between 19.60 cwt. per acre and 29.62 cwt. per acre for rotations including winter canola to generate higher average net returns per acre than typical rotations without winter canola. Table 3 shows the various yields at which rotations including either spring or winter canola generate higher net returns per acre than typical rotations without canola. The yields listed in the left column are the minimum yields necessary for the average net returns per acre from the rotation including canola to just exceed the average net returns per acre from the specific rotation without canola.

North Dakota

In the north central section of North Dakota, wheat is the predominant crop. Traditional rotations in the region include 50 percent of the available acreage in some combination of Durum and other (typically Hard Red Spring) wheat, with the remaining acreage split between another grain crop (spring barley or oats) and an oilseed crop (sunflowers, flaxseed, crambe or spring canola). Using 1988 to 1995 data, the net returns per acre were determined for the area's typical rotations. The average net returns per acre for these rotations are listed and ranked from high to low in Table 4.

Table 4: Net returns per acre by rotation, North Dakota: 1988–1995

	DBHS	DBHC	DBHN	DOHS	DOHC	DBHF	DOHN	DOHF
1988	$(5.68)	$0.44	$(0.77)	$(5.64)	$0.44	$(8.66)	$(0.73)	$(8.62)
1989	$16.81	$21.07	$19.03	$5.37	$9.63	$12.23	$7.59	$0.79
1990	$38.00	$31.71	$31.97	$25.78	$19.49	$25.13	$19.75	$12.91
1991	$45.20	$38.49	$34.59	$34.67	$27.96	$24.66	$24.05	$14.13
1992	$30.09	$22.86	$19.11	$20.07	$12.84	$14.73	$9.09	$4.71
1993	$52.28	$48.51	$45.42	$55.16	$51.40	$40.96	$48.30	$43.84
1994	$46.57	$46.06	$44.25	$35.96	$35.18	$31.26	$33.37	$20.39
1995	$58.88	$59.27	$56.47	$43.86	$44.25	$44.78	$41.45	$29.76
Avg.	$35.27	$33.55	$31.26	$26.90	$25.15	$23.14	$22.86	$14.74
Rank	1	2	3	4	5	6	7	8
Range	64.6	58.8	57.2	60.8	51.0	53.4	49.0	52.5
Std Dev	21.1	18.7	18.3	20.0	17.7	17.2	17.3	16.7

Key to rotations:

DBHS = Durum-Barley-Hard Red Spring Wheat-Spring Canola
DBHF = Durum-Barley-Hard Red Spring Wheat-Flaxseed
DBHC = Durum-Barley-Hard Red Spring Wheat-Crambe
DOHN = Sunflower-Durum-Oats-Hard Red Spring Wheat
DBHN = Durum-Barley-Hard Red Spring Wheat-Sunflower
DOHF = Durum-Oats-Hard Red Spring Wheat-Flaxseed
DOHS = Durum-Oats-Hard Red Spring Wheat-Canola

Analysis of the variance of net returns per acre within and between these rotations indicated that any differences in average net returns per acre were not statistically significant. Because of the price and yield fluctuations for individual crops over the 1988 to 1995 period, significant differences between net returns per acre for each rotation could not be identified. Wheat (durum or hard red spring) is the most profitable crop in the region, and acreage is usually limited by rotational constraints and in the past, by government grain-program acreage restrictions. Because the above rotations all include 50 percent of available acreage in wheat, the average net returns per acre and the year-to-year variability of those net returns are highly dependent on the net returns per acre and the annual variability of net returns to the wheat crop.

The t test showed only DOHF different from the highest income rotation (DBHS). Figure 10 indicates the relationship between average income and standard deviations for the rotations considered. In this case the rotation with the highest income (DBHS) also had the greatest s.d. or income variation. Both spring canola and crambe were favored over sunflower and oats. However, all of the North Dakota standard deviations fell within a rather narrow range.

At 1988 to 1995 average prices and yields, rotations that included either spring canola or crambe typically generated between 8 percent and 30 percent higher net returns per acre than did the same rotations including the other oilseed crops - sunflower and flaxseed.

During the eight-year period, the price of LEA rapeseed (canola) in North Dakota fluctuated between \$9.72/cwt. and \$11.10/cwt. (average \$10.39/cwt.). The price for crambe ranged from \$9.50/cwt. to \$10.00/cwt. (average \$9.75/cwt.) over the period[3]. Yields for canola ranged from 6.6 cwt. to 14.2 cwt. (average 11.3 cwt.) per acre over the period and yields for crambe ranged between 8.9 cwt. and 13.5 cwt. (average 10.8 cwt.) per acre over the period between 1988 and 1995.

Using the GAMS model, it was determined that, at the average 1988 to 1995 yield for canola, the average price per pound could fall by as much as \$1.31 (to \$9.08/cwt.) before spring canola would begin to lose its advantage in profitability over the traditional oilseeds, sunflower and flaxseed. Similarly, at the 1988 to 1995 average price, canola yields per acre could fall by as much as 1.44 cwt./acre (to 9.89 cwt./acre) before canola lost its profitability advantage over sunflower or flaxseed. Tables 5 and 6 show the various average prices per cwt. and yields per acre below which rotations including spring canola generate lower net returns per acre than do typical rotations including other oilseed crops.

Table 5: Prices below which canola loses its profitability advantage against other oilseeds in typical North Dakota rotations, at typical average yields.

Suggested price (\$/cwt.)	Spring canola (Avg. Yield 11.2 cwt.)
@\$6.57 / cwt.	DOHS > DOHF
	DBHS > DBHF
@\$9.08 / cwt.	DOHS > DOHN
	DBHS > DBHN
@\$9.70 / cwt.	DOHS > DOHC
	DBHS > DBHC

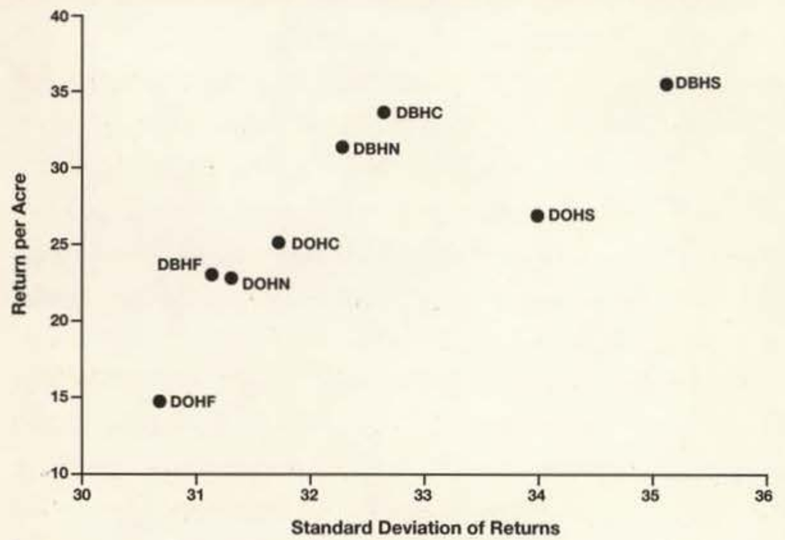
Table 6: Yields below which canola loses its profitability advantage against other oilseeds in typical North Dakota rotations, at typical average prices.

Suggested yield (\$/cwt.)	Spring canola (Avg. \$10.39/cwt.)
@ 7.16 cwt./acre	DOHS > DOHF
	DBHS > DBHF
@ 9.89 cwt./acre	DOHS > DOHN
	DBHS > DBHN
@ 10.61 cwt./acre	DOHS > DOHC
	DBHS > DBHC

Similarly, the GAMS model was used to determine, at 1988 to 1995 average prices and yields, the necessary yields per acre and prices per cwt. that would be needed for crambe to maintain its profitability advantage over other oilseeds in typical regional rotations. At the 1988 to 1995 average yield per acre of crambe, the average price received for crambe could drop to \$6.38/cwt. before crambe lost its profitability advantage over flaxseed. The average price could drop to \$9.03 before crambe lost its profitability advantage over sunflowers. However, the average price of crambe would have to increase to \$10.42 / cwt. for rotations including crambe to generate higher net returns per acre than the same rotations including spring canola. Similarly, at 1988 to 1995 average price for crambe, average yields could decrease to 7.06 cwt. / acre and 9.98 cwt. / acre for crambe to lose its profitability advantage over flaxseed and sunflower, respectively. Average yields for crambe would have to increase

[3] The average price of crambe is very stable because nearly all of the crambe crop is pre-contracted at a specified price, and the market for crambe in North Dakota has been restricted to a single or very limited number of buyers. Although the pre-contracting procedure is also true for canola, the number of buyers for canola in the area is relatively larger than for crambe.

Figure 10. North Dakota Alternative Rotations, 1988–1995.



to 11.52 cwt. / acre for rotations including crambe to generate greater net returns per acre than the same rotations including canola. Tables 7 and 8 show the various average prices per cwt. and yields per acre below which rotations including crambe generate lower net returns than do typical rotations including other oilseed crops.

Iowa

In the Iowa dryland region, the most common rotation is the two-year corn-soybeans rotation. In some cases, farmers in the region also include oats in the rotation as a disease and pest break. It was assumed for this study that corn was planted on 50 percent of the available land in any given year, and soybeans were planted on between 25 percent and 50 percent of available land. Using 1988 to 1995 data for corn, soybeans, and oats in the region, the net returns per acre were determined for the typical rotations. Net returns per acre for rotations including canola and crambe were also determined using cost, price, and yield data from North Dakota[4]. The average net returns per acre for each rotation are listed and ranked from high to low in Table 9.

Table 7: Prices below which crambe loses its profitability advantage against other oilseeds in typical North Dakota rotations, at typical average yields.

Suggested price (\$/cwt.)	Crambe (Avg. Yield 10.75 cwt.)
@\$6.38 / cwt.	DOHC > DOHF
	DBHC > DBHF
@\$9.03 / cwt.	DOHC > DOHN
	DBHC > DBHN
@ \$10.42 / cwt.	DOHC > DOHN
	DBHC > DBHS

Table 8: Yields below which crambe loses its profitability advantage against other oilseeds in typical North Dakota rotations, at typical average prices.

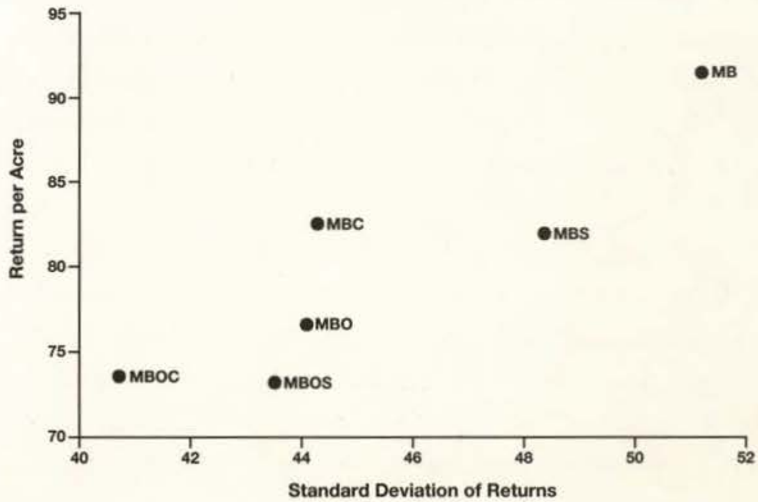
Suggested yield (cwt./acre)	Crambe (Avg.\$9.72 /cwt.)
@ 7.06 cwt./acre	DOHC > DOHF
	DBHC > DBHF
@ 9.98 cwt./acre	DOHC > DOHN
	DBHC > DBHN
@ 11.52 cwt./acre	DOHC > DOHS
	DBHC > DBHS

Although it would appear that average net returns per acre were different for the different rotations, analysis of variance of the net returns within and between rotations indicated that

[4] Although canola production was introduced in Iowa in the 1980s, producers lost interest in the crop because of low prices and difficulty in finding available markets for the crop. Therefore, data that truly reflects the costs and returns of raising canola in Iowa are unavailable. Small amounts of crambe were grown in Iowa under experiment station and on-farm conditions.

[5] Analysis of variance of the raw data resulted in an F-value of 0.19. Analysis of variance of ranked data resulted in an F-value of 0.22.

Figure 11. Iowa Alternative Rotations, 1988–1995.



those differences were not statistically significant[5]. The variability of net returns was so great between years (because of yield and price fluctuations for all crops) that no significant differences between rotations could be identified. Since corn and soybeans are the dominant crops in the region (and accounted for as much as 75 percent of available land in this model), the average net returns per acre are highly dependent upon net returns for these two crops. The variability of net returns per rotation over time would also be highly correlated to the variability of net returns per acre to corn and soybeans.

All Iowa rotations studied included corn and soybeans. The corn-soybean rotation gave the highest average return but also had the highest s.d. Canola and Crambe statistics were scarce for Iowa. However, with data available rotations including both of these crops were respectable and had higher average returns than rotations including oats, but differences were not great. Figure 11.

Table 9: Net returns per acre by rotation, Iowa: 1988 to 1995

	MB	MBC	MBS	MBO	MBOC	MBOS
1988	$23.81	$20.48	$13.28	$25.58	$22.64	$17.24
1989	$74.02	$83.75	$59.65	$65.11	$74.64	$56.56
1990	$100.74	$101.21	$93.04	$84.69	$89.05	$82.93
1991	$69.29	$67.14	$68.82	$55.04	$56.99	$58.25
1992	$119.74	$106.43	$111.13	$103.08	$97.26	$100.79
1993	$32.83	$18.95	$28.16	$17.74	$11.10	$18.00
1994	$142.33	$129.55	$130.07	$119.07	$115.30	$115.69
1995	$169.36	$132.08	$151.24	$142.71	$121.42	$135.78
Avg.	$91.52	$82.45	$81.92	$76.63	$73.55	$73.16
Rank	1	2	3	4	5	6
Range	145.6	113.1	138.0	125.0	110.3	118.5
Std. dev.	51.2	44.3	48.4	44.1	40.7	43.5

Key to rotations:

MB = Corn (maize)-Soybean **MBO** = Corn (maize) Soybean-Oats **MBC** = Corn (maize)-Soybean-Crambe

MBOC = Corn (maize) Soybean-Oats-Crambe **MBS** = Corn (maize)-Soybean-Canola **MBOS** = Corn (maize)-Soybean-Oats-Canola

At 1988 to 1995 average yields and prices, the corn-soybeans rotation generated higher net returns than did rotations including oats, canola, crambe, or a combination of these three crops (Table 9). Including canola or crambe in the typical corn-soybean rotation decreased average net returns per acre by approximately 10.5 percent. Including canola or crambe in a typical corn-soybean-oat rotation did not increase net returns over the MBO rotation.

Because prices for canola and crambe were unavailable, North Dakota prices were substituted. During the eight-year period, the North Dakota price of LEA rapeseed (canola) fluctuated between $9.72/cwt. and $11.10/cwt. (average $10.39/cwt.). The price for crambe (HEA oilseed) ranged from $7.95/cwt. to $12.10/cwt. (average $9.12/cwt.) over the period. Yields for crambe grown in Iowa averaged 14.7 cwt./acre.

Using the GAMS model, it was determined that, at average 1988 to 1995 yields for canola, the price farmers received for canola would have to increase to $13.05 per cwt. and $15.71 per cwt. for rotations including canola to provide greater net returns per acre than the typical corn-soybean-oat and corn-soybean rotations, respectively. At the average 1988 to 1995 price for canola, average yields would have to be 14.24 cwt./acre and 17.15 cwt./acre for rotations including canola to provide greater net returns per acre than the typical corn-soybean-oat and corn-soybean rotations, respectively.

It was also determined that, at average 1988 to 1995 yields for crambe, the price farmers received for crambe would have to increase to $10.10 per cwt. and $12.19 per cwt. in order for rotations including crambe to generate equal or greater average net returns per acre than typical corn-soybean oat and corn-soybean rotations, respectively. At the average 1988 to 1995 price for crambe, average yields of 15.61 cwt./acre and 18.91 cwt./acre would be necessary to generate greater average net returns per acre than the typical corn-soybean-oat and corn-soybean rotations, respectively.

Tables 10 and 11 show the average prices per cwt. and yields per acre necessary for rotations including canola or crambe to generate equal or higher average net returns per acre than typical Iowa rotations without these two crops.

Georgia

Cotton and peanuts are the two most important crops grown in the dryland region of Georgia. Other crops typically grown in rotations in the region are corn (maize), soybeans, and soft red winter wheat. It was assumed for this study that dryland cotton was planted on 50 percent of the available acreage in any given year, with 25 percent of the remaining acreage planted in peanuts and the other 25 percent in some combination of the alternative crops—corn, soybeans, and wheat. Using 1988–1995 price and yield data for crops in the region, the net returns per acre were determined for the typical rotations in the area. In addition, net returns per acre were determined for the typical rotations including canola, in place of and in addition to the other alternative crops. The average net returns per acre for each rotation are listed and ranked from high to low in Table 12.

Although it would appear that the average net returns per acre were different for the different rotations, analysis of variance indicated that those net returns between rotations were not statistically significant[6]. The year to year variability of net returns for all the rotations was so great, due to yield and price fluctuations for the major crops, that no significant differences could be identified. Since dryland cotton and peanuts were the main crops in

[6]Analysis of variance of the raw data resulted in an F-value of 0.08. Analysis of variance of ranked data resulted in an F-value of 0.19.

this model and accounted for 75 percent of the acreage, the average net returns for all the rotations were highly dependent upon the net returns for these two crops. Hence, the variability of net returns per rotation would be highly correlated to the variability of net returns per acre for cotton and peanuts.

Table 10: Prices that would be necessary to bring canola or crambe into typical Iowa rotations, at typical average yields.

Suggested price ($/cwt.)	Canola (Avg. Yield 11.3 cwt.)	Crambe (Avg. Yield 14.2 cwt.)
@$10.10/cwt.		MBOC > MBO
@$12.19/cwt.		MBC > MB
@$13.05/cwt.	MBOS > MBO	
@$15.71/cwt.	MBS > MB	

Table 11: Yields that would be necessary to bring canola or crambe into typical Iowa rotations, at typical average prices.

Suggested yield (cwt./acre)	Canola (Avg. $10.39/cwt.)	Crambe (Avg.$9.12/cwt.)
@14.24 cwt./acre	MBOS > MBO	
@15.61 cwt./acre		MBOC > MBO
@17.15 cwt./acre	MBS > MB	
@18.91 cwt./acre		MBC > MB

Analysis of the Georgia data again showed no significant differences between the high and low average net incomes at the 95 percent level. However, the Mean-variance test showed that the rotation having the highest average income also had the lowest standard deviation. This rotation (DPS) and the second highest (DPMS) make a strong case for canola in the rotation. Figure 12

Using the GAMS model, rotations including canola generated higher net returns per acre than did the same rotations without canola (Table 12). At 1988 to 1995 average yields and prices, a dryland cotton-peanuts-canola rotation generated the highest net returns of all the rotations studied. Including canola in the typical rotations generally increased average net returns per acre by 6 percent or more.

During the 1988 to 1995 period, the price for canola in Georgia fluctuated between $11.62 and $15.38 per cwt. (average $12.86/cwt.). Canola yields for the period ranged from 11.5 cwt./acre to 19.0 cwt./acre (average 18.0 cwt./acre).

Using the GAMS model, it was determined that, for canola at 1988 to 1995 average yields in Georgia to be a profitable addition to typical Georgia rotations, the average price paid for canola would have to be between$7.58 and$10.86 per cwt. At an average price of $7.58/cwt., canola replaces wheat, the least profitable alternative crop in Georgia rotations. At $8.66/cwt. and at $10.86/cwt., canola replaces soybeans and corn, respectively, in typical Georgia rotations. Table 13 shows the various average prices per cwt. below which canola loses its profitability advantage in typical Georgia rotations.

Figure 12. Georgia Alternative Rotations, 1988–1995.

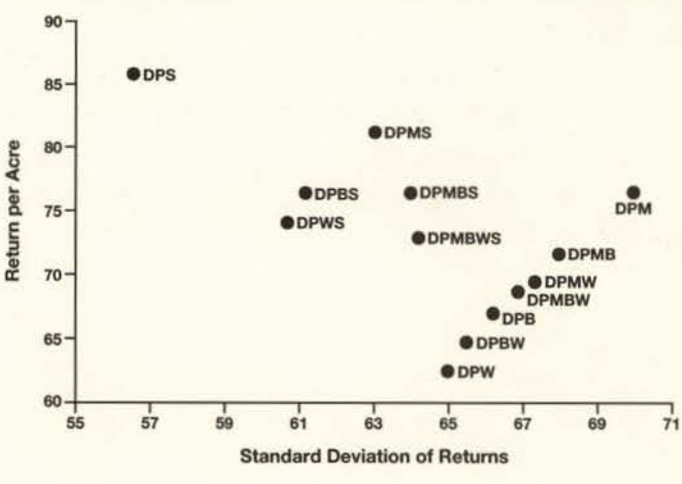


Table 12: Net returns per acre by rotation, Georgia dryland: 1988 to 1995

	DPS	DPMS	DPM	DPMBS	DPBS	DPWS	DPMBWS	DPMB	DPMW	DPMBW	DPB	DPBW	DPW
1988	$29.48	$11.39	$(6.65)	$8.88	$16.67	$12.13	$5.36	$(1.41)	$(5.95)	$(2.68)	$3.87	$(0.67)	$(5.21)
1989	$68.04	$65.43	$62.82	$59.81	$58.31	$55.89	$55.79	$55.69	$53.28	$51.71	$48.57	$46.15	$43.74
1990	$52.67	$42.42	$32.17	$33.99	$34.90	$38.98	$31.81	$24.64	$28.73	$24.86	$17.12	$21.21	$25.29
1991	$102.88	$103.84	$104.81	$97.86	$94.38	$86.80	$91.07	$95.34	$87.76	$87.14	$85.88	$78.30	$70.72
1992	$96.09	$91.46	$86.83	$88.25	$88.64	$88.05	$86.19	$84.34	$83.42	$82.90	$81.84	$80.93	$80.02
1993	$22.75	$9.38	$(3.99)	$2.21	$5.31	$4.87	$(1.60)	$(8.06)	$(8.50)	$(9.71)	$(12.14)	$(12.57)	$(13.01)
1994	$198.13	$199.02	$199.91	$195.29	$192.98	$192.50	$193.18	$193.87	$193.39	$191.54	$187.82	$187.35	$186.87
1995	$115.52	$125.75	$135.97	$124.59	$118.91	$112.79	$120.96	$129.13	$123.01	$122.77	$122.29	$116.17	$110.05
Avg.	$87.50	$81.09	$76.48	$76.36	$76.26	$74.00	$72.85	$71.69	$69.39	$68.57	$66.91	$64.91	$62.31
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13
Range	175.4	189.6	206.6	193.1	187.7	187.6	194.8	201.9	201.9	201.3	200.0	199.9	199.9
Std. Dev.	56.6	63.5	70.9	64.6	61.6	61.0	64.8	68.8	68.1	67.6	66.9	66.1	65.6

Key to rotations:

DPS = Dryland Cotton-Peanuts-Canola **DPMB** = Dryland Cotton-Peanuts-Corn (Maize)-Canola

DPMS = Dryland Cotton-Peanuts-Corn (Maize)-Canola **DPMW** = Dryland Cotton-Peanuts-Corn (Maize)-Soybeans

DPM = Dryland Cotton -Peanuts-Corn (Maize) **DPMBW** = Dryland Cotton-Peanuts-Corn (Maize)-Soybeans-Wheat

DPMBS = Dryland Cotton-Peanuts-Corn (Maize)-Soybeans-Canola **DPB** = Dryland Cotton-Peanuts-Soybeans

DPBS = Dryland Cotton-Peanuts-Soybean-Canola **DPBW** = Dryland Cotton-Peanuts-Soybean-Wheat

DPWS = Dryland Cotton-Peanuts-Wheat-Canola **DPW** = Dryland Cotton-Peanuts-Wheat

DPMBWS = Dryland Cotton-Peanuts-Corn (maize)-Soybean-Wheat-Canola

Similarly, the GAMS model was used to determine, at the 1988 to 1995 average price of $12.86 per cwt., the necessary yields per acre for canola to maintain canola's profitability advantage over other crops in typical Georgia rotations. At an average yield above 10.61 cwt./acre, canola replaces wheat in typical rotations. At average yields above 12.12 cwt./acre and 15.20 cwt./acre, canola maintains a profitability advantage over soybeans and corn, respectively, in typical Georgia rotations. Table 14 shows the minimum average yields per acre necessary for rotations including canola to generate higher average net returns per acre than typical Georgia rotations without canola.

The preceding analyses were based on constant yields and the budgets that were estimated. Each area and farm have unique conditions that will vary from the assumed norm. For this reason, each farm operator should make his or her own analysis based on costs and yields for a particular farm. Also some claim that other benefits accrue from producing these oilseed crops, such as higher wheat yields following them, better root penetration of the soil, better weed control and others. While these may be positive factors favoring rapeseed, canola, or crambe, no hard data were found to substantiate these claims, and these possible benefits were not included in the analysis. More research is needed on this subject to further investigate these possible benefits.

Table 13: Prices below which canola loses its profitability advantage against other crops in typical Georgia rotations, at typical average yields.

Suggested price (\$/cwt.)	Canola (Avg. Yield 18.0 cwt.)
@\$7.58 / cwt.	DPS > DPW
	DPMS > DPMW
	DPBS > DPBW
	DPWS > DPW
	DPMBS > DPMBW
@\$8.66 / cwt.	DPS > DPB
	DPMS > DPMB
	DPBS > DPB
	DPWS > DPBW
@\$9.03 / cwt.	DPMBWS > DPMBW
@\$9.76 / cwt.	DPMBS > DPMB
@\$10.86 / cwt.	DPS > DPM
	DPMS > DPM
	DPBS > DPMB
	DPWS > DPMW

Table 14: Yields below which canola loses its profitability advantage against other crops in typical Georgia rotations, at typical average prices.

Suggested yield (cwt./acre)	Canola (Avg. \$12.86/cwt.)
@10.61 cwt./acre	DPS > DPW
	DPMS > DPMW
	DPBS > DPBW
	DPWS > DPW
	DPMBS > DPMBW
@12.11 cwt./acre	DPWS > DPBW
@12.12 cwt./acre	DPS > DPB
	DPMS > DPMB
	DPBS > DPB
@12.64 cwt./acre	DPMBWS > DPMBW
@13.66 cwt./acre	DPMBS > DPMB
@15.20 cwt./acre	DPS > DPM
	DPBS > DPMB
	DPWS > DPMW
	DPMS > DPM

Summary and conclusions

Initially this project was begun under a national committee promoting the possible use of crops containing high erucic acid oils as alternative crops in the United States. Rapeseed was the principal crop being assessed but crambe was also considered. There were two main thrusts to develop crop varieties that would give satisfactory yields and contain a high percentage of oil and second, to find new and existing uses for high erucic acid oil and to commercialize these uses.

One of the economic objectives was to attempt to predict areas within the United States where these crops were likely to compete best with other crops in typical rotations. States were chosen to be somewhat representative of the Pacific Northwest, the Northern Plains, the cornbelt, and the southeastern states. Idaho, North Dakota, Iowa, and Georgia were chosen for study.

As the project progressed, most areas with interest in HEA rapeseed shifted their interests to canola. Therefore, the analysis also followed this trend and canola became a principle commodity in the analysis. However it was found that production costs for industrial rapeseed and canola were essentially the same. Only the markets were different. The problem addressed was to determine if crop rotations in each of the areas would be more profitable or less profitable after the addition of rapeseed or crambe.

Budgets were prepared for principal crops in each area as well as for the introduced oilseed crops. Analyses were made using the General Algebraic Modeling System (GAMS). Several crop rotations were considered for each area with and without rapeseed or crambe. Using actual average yields and prices for 1988 to 1995 an estimate of net cash income was made for each rotation. This gave an estimate of return per acre for each rotation. Then the price and yield necessary for rapeseed or crambe to enter the rotation was estimated. To enter the rotation the net returns had to be higher than an existing alternative.

It was found that winter canola was more profitable than barley or peas in Northern Idaho. Spring canola and crambe were more profitable than flax or oats and similar in profit to barley and sunflower in North Dakota. Crambe and spring canola could compete with oats in Iowa, but corn and soybeans dominated cropland use there. Spring canola can compete with wheat, corn or soybeans in Georgia based on price and yield data available at the time of the study.

In Northern Idaho, the price of rapeseed or canola had to be at least $10.60 per cwt at the average yield to enter the least profitable rotation and as high as $17.73 to enter the most profitable rotation. Or, if price were held constant at the 1988-95 average, yields of spring canola would need to be 1800 lbs. to enter the lowest income rotation and 2300 lbs. to enter the highest one. For winter canola, the yields required were 19.6 cwt to 29.6 cwt. Increased average yields are expected as farmers gain experience and new seed varieties are developed.

North Dakota estimates show that canola begins competing with other crops at $6.57 per cwt and would need to be at least $9.70 to compete with the better rotations. At average prices, yields would have to range from at least 716 lbs. to 1,016 lbs. per acre to net more than alternative crops. Figures for crambe in North Dakota show that it could compete with low-income crops at a price of $6.38 per cwt and must rise to at least $10.42 per cwt to compete with more profitable crops. Competitive yields at average prices were from 706 to 1,152 pounds per acre.

Prices for canola in Iowa at average yields would need to be at least $13.05 per cwt and over $15.71 if canola were to enter the corn-soybean rotation. Yields at average prices had to be 1,424 lbs. per acre to compete with low-income crops and at least 1,715 lbs. to enter the corn-soybean rotation.

The price required for canola to enter Georgia's rotations was $7.58 per cwt. At this price canola replaced wheat in the rotation and at $10.86 it replaced corn. Yields would need to be at least 1,061 pounds per acre to replace wheat and rose to 1,520 pounds in order to replace corn at average prices.

To summarize, crambe can compete with lower value rotation crops in North Dakota. There seems to be no real interest in crambe in the other areas studied. Canola is a possibility in any of the study areas and in some years it has been as profitable or more profitable than some more traditional crops. Improvement of yields or prices could make this an attractive crop in all of the areas except, perhaps, Iowa where corn and soybeans are strong competitors. Of the areas studied, North Dakota is the only area where there has been major production of crambe and this also seems to be an area favorable to canola production. Canola also looks very competitive in Georgia. Canola can be considered in Idaho along with other lower income crops such as barley or peas.

Observations

1. Crambe is now an economic alternative to lower valued crops in North Dakota.
2. Canola is profitable for North Dakota farmers and possibly for the surrounding area.
3. Canola is profitable in Georgia as a replacement for wheat.
4. Canola is a marginal crop for Northern Idaho. Some farm operators have been successful and others have not with this crop. Improved seed varieties may increase productivity in the future. Rotational benefits need further study.

5. Winter rapeseed or canola is competitive in Northern Idaho where land is fallowed. Eastern Washington and Oregon would probably be similar in this regard.
6. Iowa is not likely to produce significant amounts of either canola or crambe under current prices and production scenarios.

The analysis for this report was made using the information found for prices and yields from 1988 to 1995. Production costs were based on budgets obtained from each of the study areas. Results and conclusions may change as relative prices, yields and production costs change in the future. Demand and supply conditions for both domestic and foreign grown commodities have and will continue to determine prices. Canola and crambe will have to compete with other domestic crops as well as canola and crambe oils from foreign sources. Currently a large part of our supply of these oils is imported indicating considerable room for production expansion if the price is right.

More work needs to be done in the future to analyze the effects of new advances in seed production and cultural practices. As both canola and crambe are relatively new crops, farmers are still learning how to produce them more efficiently.

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