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Crambe as a Specialty Crop in North Dakota

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Highlights

Crambe is an oil seed crop, which has recently been commercialized for production by farmers. Initial products manufactured from crambe include high erucic acid oil and high protein meal. Crambe seed contains about 35 percent oil, which is between 50 to 60 percent erucic acid. Crambe oils have high fire points and function excellent as lubricants under high pressure or high temperatures. Crambe meal can be fed to ruminant animals in finishing rations at levels not to exceed about 4 percent of the total ration; however, because of the high glucosinolate levels in crambe meal, it is not suitable for swine and poultry. Research is underway to lower the glucosinolate levels in crambe meal.

At the current price of $9.50 per cwt., crambe is economically competitive with crops typically produced in central North Dakota. Crambe has greater net returns than flax, corn, oats, barley, and oil sunflowers. A linear programming model, was developed to analyze the profitability of adding crambe to existing farms in central North Dakota. Based on current farm program requirements, crop prices, crop yields, and production costs, returns over variable costs increased 8.5 percent when farms added crambe to their crop production. Crambe replaced barley and corn, reducing the model farm's dependence on farm program payments.

Crambe has been successfully grown across the United States. Central North Dakota is advantageous to the production of crambe because of its shorter growing season and its lower probability of heat stress. Other areas of the state pose greater risks of heat stress which can be detrimental to yields. Crambe can be effectively produced using machinery and equipment required for small grains, which facilitates the transition into crambe production.

CRAMBE AS A SPECIALTY CROP IN NORTH DAKOTA

Randall S. Sell, David L. Watt, and Roger G. Johnson*

INTRODUCTION

Commercial-scale production of crambe (*Crambe abyssincia* Hochst), an oil seed crop which has recently been commercialized for production by farmers, is beginning in North Dakota. Initial products manufactured from crambe include high erucic acid oil and high protein meal. High erucic acid oil is a complement to petroleum products used by United States industries. The crambe meal is used as a protein supplement in ruminant diets.

The high erucic acid oil extracted from crambe seed can serve as the raw material for many products important to various industries. One of the most important products is erucamide, used as a slip promoting additive in various plastic manufacturing processes. The United States uses 40 million pounds of high erucic acid oil per year, most of which is imported (Van Dyne et al., 1990). There is potential for expanded use.

The United States Treasury is facing tighter economic constraints every year. Agricultural producers in the United States are under pressure to reduce farm program costs. A better use for agricultural resources might be to incorporate a policy option subsidizing the production of crops with industrial uses such as crambe or, at least, allowing these crops to be produced without penalty in government programs.

The remaining portions of this report are divided into four sections. Crambe oil products, by-products, and potential uses are included in the first section. Agronomic characteristics that make crambe an attractive alternative crop for North Dakota are presented in the second section. The remaining sections of the report consider the economics of producing crambe in North Dakota.

PRODUCTS AND USES

High erucic acid oil and defatted meal are the initial products from processed crambe seed. The product flow from crambe seed through intermediate products to end uses is shown in Figure 1. Crambe oil is extracted either by mechanical press, solvent extraction, or pre-press/solvent extraction.

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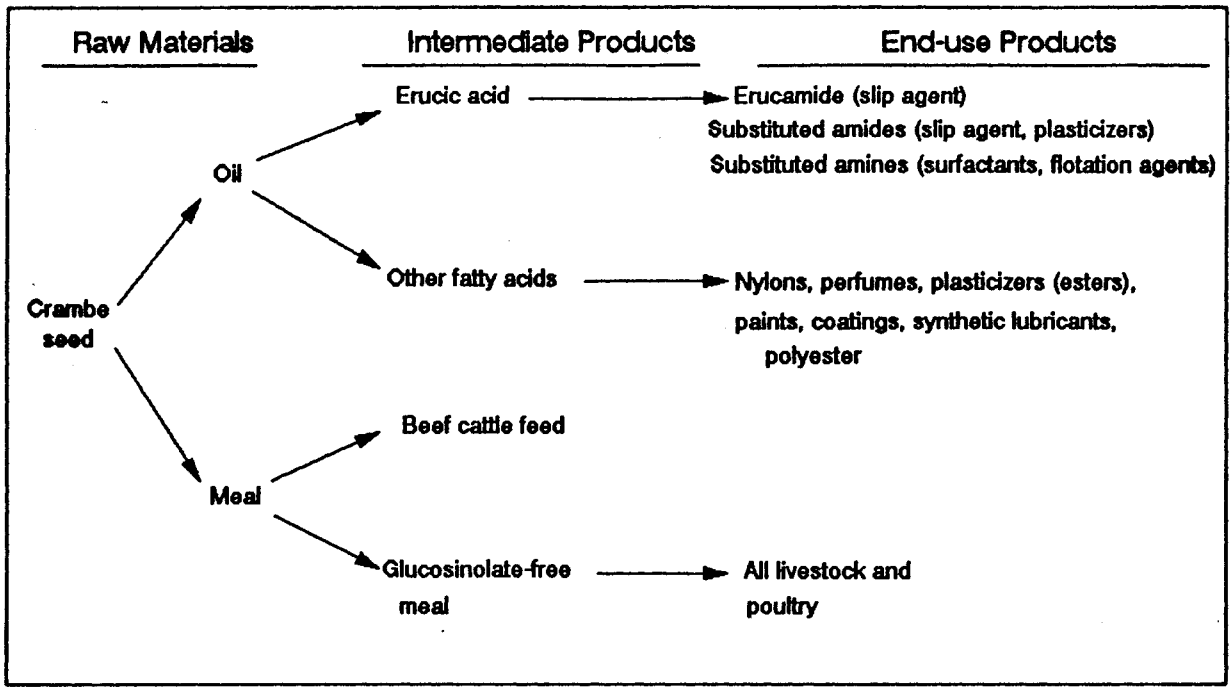

Figure 1. Intermediate and End-use Products From Crambe Seed

SOURCE: Van Dyne et al., 1990.

Crambe oil has much greater economic value than the meal. Crambe oil is high in erucic acid (50 to 60 percent) and is incredibly stable at high temperatures. Crambe oils have high fire and smoke points, which enable them to withstand the high temperatures which lubricating and heat transfer oils are subjected, yet remain fluid at lower temperatures (Kramer et al., 1983). With these properties, crambe works exceptionally well as a lubricant or as a lubricant additive, enhancing the performance of lubricants at high temperature or high pressure conditions.

Patents for several derivatives of erucic acid have been either issued or applied for. These derivatives are used as processing aids, surfactants, plasticizers, corrosion inhibitors, and conditioners. Probably the best known of the derivatives is erucamide, which is added to plastics in low concentrations to prevent film sheets from adhering to one another and is used as a lubricant to speed the manufacture of plastic parts.

Crambe meal can be used as a protein supplement for beef cattle. Rapeseed meal, which is similar in nutrient content and glucosinolate levels, was fed as a pelleted protein supplement to compare it with soybean meal in a finishing beef ration. Results indicate that steers fed rapeseed meal performed as well as steers fed soybean meal. Also, animals fed rapeseed meal graded

higher than those fed soybean meal (Heidher and Klopfenstein, 1989). A feeding trial comparing crambe meal to soybean meal as a protein supplement was implemented at the Carrington Research Extension Center in the fall of 1991. Initial results indicate that calves fed crambe meal perform as well as, or better than, calves fed soybean meal (Anderson, 1992).

Since crambe meal has levels of glucosinolates that can be toxic to swine and poultry, research is ongoing to reduce glucosinolate content to safe levels for poultry and swine (Baker et al., 1977; Diosady et al., 1985). The U. S. Food and Drug Administration has approved solvent-extracted crambe meal for use in beef cattle finishing rations at a concentration not to exceed 4.2 percent of the total weight of the ration (Carlson and Tookey, 1983; Association of American Feed Control Officials, Inc., 1989).

PRODUCTION

Crambe has been successfully grown in California, Illinois, Indiana, Iowa, Kentucky, Montana, Nebraska, New Mexico, North and South Dakota, Ohio, Oregon, Texas, Washington, and Wyoming (White and Higgins, 1966). Crambe is a cool season annual that requires fertile, well-drained soils for best performance. North Dakota is the most recent site for a commercial-scale crambe production. Yields in North Dakota in 1990 ranged from 321 to 2,121 pounds per acre (Gardner et al., 1991). Crambe in North Dakota yields between 24 and 36 percent oil, which contains between 50 and 60 percent erucic acid (Gardner et al., 1991). Crambe is generally reported to have an average oil content of 35 percent with some dehulled crambe seed approaching 50 percent oil (Van Dyne et al., 1990). Crambe seed composition is shown in Table 1.

Crambe is susceptible to turnip mosaic virus and alternaria (Christmas et al., undated; Woolley and Lovely, 1988). Crambe is tolerant to drought; however, heat stress at the flowering stage can be detrimental to yields (Gardner, 1991; McKay, 1991). Broadleaf weeds exhibited the greatest competition in crambe stands in North Dakota, according to a survey of 38 farmers who participated in a field-scale evaluation of crambe (Gardner et al., 1991). Weed competition was the predominant factor responsible for the variability of crambe yields reported in 1990. No herbicides are currently labeled for use on crambe.

Farmers will be more likely to adopt alternative crops and cropping systems if those crops can be assimilated into the existing farm operation with little added investment and/or require similar management expertise. Crambe production in North Dakota can use the 'typical' machinery complement, storage facilities, and management capabilities of the small grain farmer. According to research in North Dakota (McKay, 1991),

TABLE 1. COMPOSITION OF CRAMBE SEED

Item	Crambe seed
	100 percent dry matter basis
	percent
Oil	35.3
Protein (Nx6.25)	20.1
Crude fiber	14.3
Nitrogen-free extract	25.4
Fatty acid composition	
Erucic	50-60
Oleic	15
Linoleic	10
Linolenic	7
Eicosenoic	3
Palmitic	2
Behenic	2

SOURCE: Van Dyne et al., 1990.

crambe should be planted in early May but no later than May 15. The inputs required for crambe production are similar to other crops produced in North Dakota (Endres and Schatz, 1991). Crambe has been planted with press drills, swathed, and combined effectively with the same equipment used for barley, flax, oats, and wheat.

Crambe is a relatively bulky commodity, similar in weight per bushel to sunflower. Therefore, transportation costs are greater than for wheat, barley, flax, and corn but similar to sunflower. Nitrogen and phosphorus needs are comparable to wheat. Crambe requires slightly less fuel per acre to produce than does spring wheat (Appendix A). Since crambe production is similar to other small grains, adoption of crambe as an alternative crop depends on the relationship of risk and return for crambe versus competing crops.

ECONOMIC ANALYSIS

Production area

The field-scale production in North Dakota provided excellent information for analyzing the economics of crambe production. Foster County was the location used to study crambe production in North Dakota, as crambe is most likely to be produced in the east-central area of the state. At current price

levels, crambe will have difficulty competing with higher valued crops produced in the Red River Valley. The more arid portions of western North Dakota are not as suited to crambe production, since it is sensitive to high temperatures and low moisture conditions.

Central North Dakota seems to have a comparative advantage over western North Dakota for the production of crambe. Yields of crambe were compared to yields of spring wheat and barley at two experiment stations in western North Dakota (Williston and Dickinson) and three stations in central North Dakota (Carrington, Langdon, and Minot) (Table 2). Crambe yields were higher relative to spring wheat and barley in central North Dakota than in western North Dakota. Another reason for selecting central North Dakota was because it had the greatest number of farmers cooperating in the 1990 field-scale evaluation. This was due, in part, to the location of the plant processing the crambe (National Sun Industries located at Enderlin) and the promotional efforts of the Carrington Research Extension Center.

TABLE 2. RATIO OF POUNDS OF WHEAT AND BARLEY PRODUCED PER POUND CRAMBE PRODUCED AT TWO WESTERN NORTH DAKOTA AND THREE CENTRAL NORTH DAKOTA EXPERIMENT STATIONS, 1989-1990

	Pound of crambe/pound of crop	
Crop [a]	Western [b]	Central [c]
Crambe vs barley	.35	.44
Crambe vs wheat	.47	.54

[a] Wheat, barley, and crambe yields were averaged across all varieties.
[b] Western experiment stations included Williston and Dickinson.
[c] Central experiment stations included Minot, Langdon, and Carrington.

Model farm development

The Census of Agriculture data were used to determine 'typical' acreage of woodland, wasteland, pasture, cropland and harvested land for an average farm located in Foster County (Bureau of the Census, 1987). Crops to be grown on the model farm were then determined by examining the percentage of all farms growing each crop and the percentage of total crop acres devoted to each crop.

Census data for farms with $10,000 or more in sales were used when available. Wasteland, native pasture, and woodland was

subtracted from total land to estimate cropland. Cropland acres minus cropland used for pasture, cover crops, idle cropland, summer fallow, and acres of crop failure equaled harvested acres. Total acres of wheat, feed grains (barley, oats, and corn for grain and silage), row crops (dry edible beans and sunflower), and miscellaneous crops were determined on a weighted average basis.

Wheat, feed grains, row crops, and miscellaneous crops represented 35.4, 10.6, 19.5 and 9.9 percent of cropland, respectively (Bureau of the Census, 1987). Cropland in other uses (summer fallow and diverted land) accounted for about 24.7 percent of total cropland. The average farm size for Foster County was equal to total cropland (331,065.8 acres) divided by the number of farms with $10,000 or more in sales (307) or 1,078 acres (Table 3). Actual average cropland acres may be lower because farms with less than $10,000 in sales were not included.

TABLE 3. ESTIMATES OF ACREAGE FOR MODEL FARM FOSTER COUNTY, NORTH DAKOTA, 1987

Land description and use	County total		County average		Model farm	
	base [a]	cropped	base	crop	base	crop
	acres					
Wheat	161,479	117,073	526	381	642	465
Barley	23,934	19,147	78	62	95	76
Oats	9,059	7,247	30	24	36	29
Corn	10,713	8,570	35	28	43	34
Sunflower		63,340		206		252
Dry edible beans [b]		1,038		3		
Misc. crops						
All Hay [b]		16,078		52		
Rye [b]		1,805		6		
Flax		2,718		9		11
Land-tame pasture [b]		12,210		40		
Diversion		53,147		173		211
Summer fallow [b]		28,693		93		
Total Cropland		331,066		1,078 [c]		1,078

[a] Base acres for program crops assuming 100 percent participation rate in wheat and feed grain programs in 1987. Therefore, the difference between the base and crop acres of farm program crops is representative of the ARP requirements in 1987.

[b] Acres of dry edible beans, all hay, rye, land in pasture, and summerfallow were allocated to crops included within the model farm.

[c] Based on 307 farms with $10,000 or more in sales (Census of Agriculture, 1987).

SOURCE: Bureau of the Census, 1987.

The model farm in Foster County grew wheat, barley, oats, corn for grain, oil sunflower, and flax. Because of the high percentage of farmers participating in the farm program, 100 percent participation in the 1991 farm program was assumed. Acres of dry edible beans, hay, rye, and summer fallow were allocated to wheat, barley, oats, corn, sunflower and flax acres based on percent of existing acres.

A budget generator program (COMPBUD) developed by Edwardson and Hughes (1988) was used to estimate budgets for crops. COMPBUD is a computerized budgeting tool designed to help individual producers develop cost projections for all aspects of crop production. Extension service 1991 crop budgets were modified to determine revenue, fixed and variable costs, and net returns.

Returns over variable costs were determined for all crops. A ten-year average (1981-1990) of Foster County yields was used as a proxy for crop yields in the model farm (Appendix B). The yield for crambe was 1054 lb./acre, which represents 75 percent of a three-year average (1988-1990) at the Carrington Research Extension Center. The research center's yield was adjusted by 75 percent because farm yields are generally less than experiment station yields. That is due to smaller plot size, decreased ability to control pests in larger farm fields, and increased harvest losses in farm size fields.

The target and loan prices specified within the farm bill affect prices for program crops (wheat, barley, corn, and oats). Therefore, the prices used to calculate revenue were a four-year average (1986-1990). The 1988 price was not used because the distortion caused by the nationwide drought was not reflective of normal price conditions and its inclusion would unduly bias the five-year average. The crambe industry has not developed an open market for price discovery. The price used for crambe was $0.095/lb, which was the contract price that the National Sun Industries paid in 1990 to farmers cooperating in the farm-level evaluation (Gardner et al., 1991). The National Sun Industries crambe price was based on the 1990 world price for high erucic acid oil. Crop prices and yields used by year for Foster County are shown in Appendix B. Average crop yields and prices used in the model farm are shown in Table 4.

Government farm program

The farm program affects net returns over variable costs. Therefore, Foster County established yields from the Foster County Agricultural Stabilization and Conservation Service (ASCS) were used for spring wheat, corn, barley, and oats in 1990. ASCS-established yields are calculated using individual farm yields as a five-year average with the high and low yields

TABLE 4. AVERAGE YIELDS AND MARKET PRICES FOR CROPS USED IN MODEL FARM, NORTH DAKOTA, 1991

	Spring Wheat						Oil	
	Fallowed	Recropped	Barley	Flax	Corn	Oats	Sunflower	Crambe
	bushel/acre						lbs.	
Yield	33.0	29.5	45.6	13.3	64.0	53.0	1211.0	1013.5[a,b]
	$/bushel						$/cwt	
Price	2.82		1.77	4.84	1.94	1.23	8.70	9.50[c]

[a] Carrington Research Extension Center yield for 'Meyer' crambe.
[b] Seventy-five percent of average yield.
[c] Delivered contract price National Sun Industry paid to crambe growers in 1990.

SOURCE: North Dakota Agricultural Statistical Service 1991.

dropped. ASCS-established yields for the program crops will likely differ from the ten-year average yields used for estimated model farm production. These yields were multiplied by the deficiency payment per bushel for each crop to determine the amount of deficiency payment per base acre. Total deficiency payments per acre are shown in Appendix A. There are no deficiency payments for oil sunflower, flax, and crambe, which are sometimes referred to as nonprogram crops or minor oil seed crops.

To receive deficiency payments, farmers must comply with certain regulations. Farmers not in compliance with the regulations may face loss of deficiency payments, additional penalties, or both. The regulations are subject to change from year to year. To qualify for deficiency payments, a farmer must idle a percentage of the base acres. This idled land is generally referred to as ARP or set-aside acres. For the 1991 crop year, the percentage of land that must remain idle was 15 percent for wheat and 7.5 percent for corn and barley. Oats had no set-aside requirement.

Another variation of the farm program is the normal flex acre designation. Normal flex acres constitute 15 percent of the base acres for wheat, corn, barley, and oats. The farmer can plant normal flex acres to the base acre crop or to another crop. Regardless of the type of crop planted on the normal flex acres, the farmer receives no deficiency payments on normal flex acres.

Farmers can also participate in variations of the farm program, such as the 0-92 program in which the farmer receives 92 percent of the deficiency payment for the crop enrolled. In

return, the farmer can plant a minor oil seed crop (oil sunflower, flax, and crambe) on the base acres or leave the land idle. The farm program set-aside and normal flex acre requirements and the 0-92 program option were included in the model farm analysis as they existed for the 1991 crop year.

Production costs

Input prices used to calculate returns over variable costs are shown in Table 5. Seed cost and seeding rate, drying cost, and hauling costs for crops typically raised in Foster County were obtained from "Estimated 1989 Crop Budgets for South Central Region of North Dakota, Farm Management Planning Guide" (Olson and Hughes, 1991). Five-year nitrogen and phosphorus soil tests for Foster County were used to estimate fertility requirements for the model farm (Dahnke, 1989). Since soils in central North Dakota generally do not require potassium, a cost for potassium fertilizer was not included in the model farm budgets. COMPBUD calculated the necessary amount of fertilizer needed to meet the yield goal for each crop. Yield goals for the model farm were 135 percent of the Foster County ten-year average yield (Toman et al., 1987). Crambe has nutrient requirements similar to spring wheat, so, spring wheat fertilizer requirements were used as estimates for crambe.

Type and amount of pesticides applied to the crops were based on recommendations of the Carrington Research Extension Center. Farm prices of various pesticides were obtained from the Ostland Chemical Company, Fargo, North Dakota. Although no herbicides are labeled for application on crambe, trifluralin is expected to be labeled by the 1992 growing season and was included as a cost in the crambe budget. If trifluralin is not approved, other weed control methods may be used, which will likely have higher costs (i.e., late planting or harrowing after planting).

The machinery complement used for the model farm was the same complement that the extension service specified in the 1991 estimated crop budgets. A listing of the machinery, fuel use, purchase price, and list price are shown in Appendix C. Hauling cost for crambe includes the transportation of crambe from the model farm to the processing plant.

Cropland was assumed to be cash rented at the 1990 average rate for Foster County (North Dakota Agricultural Statistics, 1991). Interest on variable operating expenses was calculated at 12 percent (Agweek, September 9, 1991).

TABLE 5. INPUT PRICES USED FOR ENTERPRISE BUDGET GENERATION, FOSTER COUNTY, NORTH DAKOTA, 1991

Item		$/unit
Seed:	Crambe [a]	0.26/lb.
	Spring Wheat [b]	4.50/bu.
	Barley [b]	3.50/bu.
	Flax [b]	7.00/bu.
	Oats [b]	2.50/bu.
	Corn [b]	0.95/lb.
	Oil Sunflower [b]	3.30/lb.
Selling Price:		
	Crambe [c]	9.50/cwt.
	Spring Wheat [d]	2.82/bu.
	Barley [d]	1.77/bu.
	Corn [d]	1.94/bu.
	Flax [d]	4.84/bu
	Oats [d]	1.23/bu
	Oil Sunflower [d]	13.10/cwt.
Fertilizer: [b]		
	Nitrogen	0.133/lb.
	Phosphorus	0.233/lb.
Pesticide: [e]		
	varies by type	
Fuel: [f]		
	Diesel	0.91/gal
	Gasoline	1.16/gal
Drying Expense: [b]		0.10/cwt
Hauling Expense:		
	Crambe [g]	0.55/cwt
	Other crops [b]	0.10/unit
Land:		
	Cash rent [h]	31.50/acre
Interest Rate: [i]		
	Operating capital	12.0 percent

[a] Paid by growers in 1991.
[b] Olson and Hughes, 1991.
[c] National Sun Industry Crambe Contract Price in 1990.
[d] Marketing year state four-year average price, 1986 through 1990, except for 1988. North Dakota Agricultural Statistics Service, 1991.
[e] Personal interview with sales representative for Ostland Chemical Company, July 1991.
[f] United States Department of Agriculture, 1991.
[g] Calculated cash hauling cost based on interview with Hall-GMC sales representative, 240-mile round-trip haul, with a 640-bushel tag tandem axle gas truck.
[h] North Dakota Agricultural Statistics Service, Foster County average cropland rental rate, 1991.
[i] Average short-term interest rate reported in September 9, 1991, Agweek.

Results

The linear programming model FARMPLAN was used to estimate farm-level returns over variable costs (Hughes et al., 1990). FARMPLAN included the 1991 farm program constraints. FARMPLAN required information on total crop acres, base acres, deficiency payments per bushel, established yields for program crops, and net returns over variable costs for all crops in the model farm. Total revenue and net returns over variable costs, not including farm program payments, are shown in Figure 2.

Cropping plans and net income were calculated for the model farm with and without crambe as a possible cropping alternative. The effect of introducing crambe on the model farm is shown in Table 6. Barley, corn for grain, and flax drop from the solution when crambe is introduced. Oil sunflower acreage was reduced by 18 acres. Crambe would have replaced the entire 270 acres of oil sunflower except for the four-year rotational constraint placed on crambe and oil sunflower. The four-year rotational constraint was included for two reasons: (1) linear programming does not assess 'riskiness' of a particular return over variable cost and (2) managerial requirements for disease, insect, and weed infestations are not quantified in the returns over variable cost.

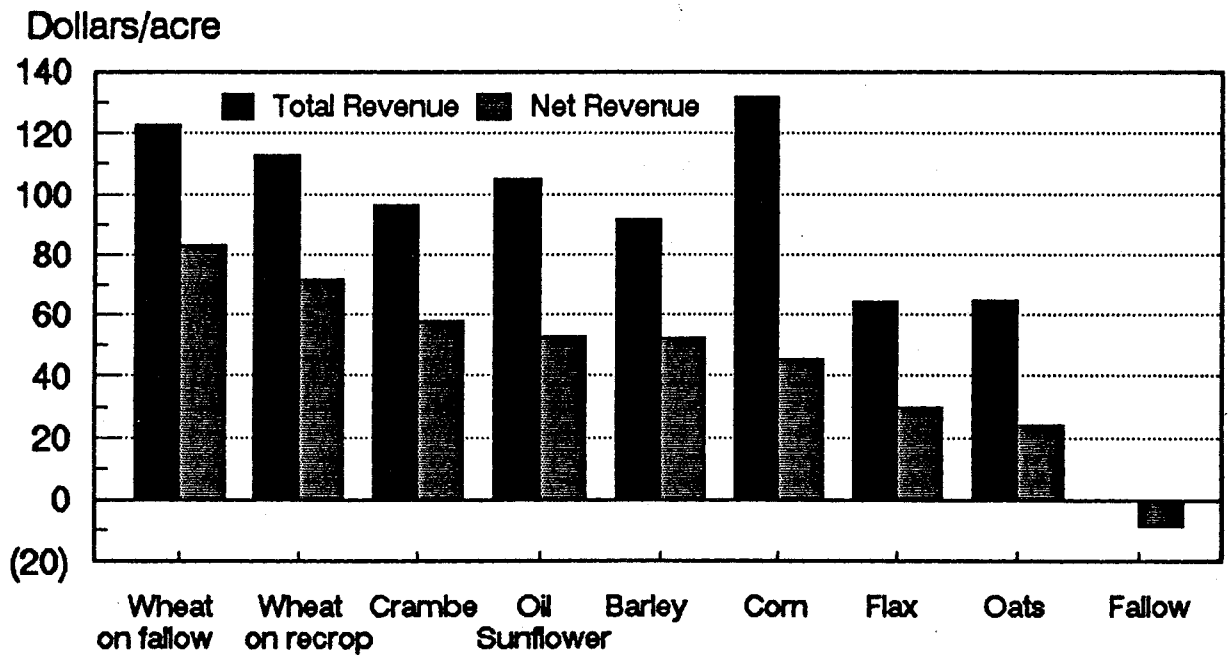

Figure 2. Total and Net Revenue per Acre by Crop for Model Farm, Not Including Farm Program Payments, Foster County, North Dakota, 1991

TABLE 6. ESTIMATED ACREAGE AND RETURNS OVER VARIABLE COSTS WITH AND WITHOUT THE POSSIBILITY OF CRAMBE PRODUCTION IN NORTH DAKOTA, 1991

Item	Model Farm without crambe	Model Farm with crambe
	----------acres----------	
Barley base	74	0
Corn grain base	33	0
Crambe[a]	---	31
Crambe on flex acres	---	114
0-92 Crambe on wheat base	---	18
0-92 Crambe on barley base	---	74
0-92 Crambe on corn base	---	33
Set-aside	107	107
Flax	23	0
Oats base	0	0
Oil sunflower[a]	270	270
Spring wheat base-recropped	342	324
Spring wheat base-fallow	107	107
Spring wheat on flex acres	122	0
Total	1,078	1,078
Net Returns over Variable Costs	$55,554	$60,288
Difference per farm		$4,734

[a] No more than 270 acres of oil sunflower or crambe could be grown because of a four-year rotational constraint (1,078 acres divided by 4 years).

Crambe increased the model farm returns over variable costs by $4,734 or 8.5 percent. The increased return does not guarantee that crambe production will be adopted in North Dakota. The increase in returns does not consider the risk of return. Farmers receive payments from the government whether or not they harvest a crop. This limits the farm's exposure to risk. Individual farmers must determine that point at which the increase in risk associated with production of crambe is worth the increased returns.

Assuming variable costs per acre were held constant, crambe would not replace barley if the return for barley increased by $2.19 per acre. With barley priced at $1.77 per bushel, this translates into an increase of barley yield of just over one bushel per acre (2.6 percent). Alternatively, if barley yield remained the same an increase in the price of barley from $1.77 per bushel to $1.82 per bushel would make barley a more viable

alternative than crambe. The percentage change in yield required for corn and flax to compete with crambe was 7 and 22 percent, respectively. The potential of crambe being a profitable specialty crop in Foster County was most sensitive to the profitability of barley followed by corn and flax.

SUMMARY

North Dakota's climatic conditions and growing seasons are suitable for the production of crambe. Initial products manufactured from crambe include high erucic acid oil and high protein meal. Crambe seed contains about 35 percent oil, which is between 50 and 60 percent erucic acid. Crambe oils have high fire points and function very well as lubricants under high pressure or high temperatures. Crambe meal can be fed to ruminant animals in finishing rations at levels not to exceed about 4 percent of the total ration; however, because of the high glucosinolate levels in crambe meal, it is not suitable for swine and poultry. Research and market development is proceeding for alternative uses of high erucic oil (Van Dyne et al., 1990).

The economic analysis indicated that crambe was competitive with crops typically grown in east-central North Dakota. However, crambe's price level relative to competing crops, once the crambe industry develops an open market for price discovery, will determine the quantity of crambe produced in North Dakota. The substitution of crambe for barley acres was the most sensitive to the returns for barley in the model farm. North Dakota farmers must also evaluate the riskiness of crambe production as a new crop, relative to crop production which the farmer is familiar with. The current United States market for high erucic acid oil is 40 million pounds, which could be satisfied with only 131,492 acres of crambe. Given this small acreage needed to meet current United States demand, crambe would be a relatively small niche market crop for North Dakota farmers.

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APPENDIX A
CROP BUDGETS FOR FOSTER COUNTY, NORTH DAKOTA, 1991

CROP BUDGET SUMMARY FOR BARLEY
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	45.6 Mkt. Yld. Goal	$80.71	$80.71
-ASCS Def. Pmt.	42.5 ASCS YLD	$11.05	$11.05
GROSS INCOME		$91.76	$91.76
* RESOURCE COMMITMENT *			
DIRECT COSTS ON	61.6 BUSHELS/ACRE		
-Seed		$5.25	$5.25
-Herbicides		$5.68	$5.68
-Fungicides		$1.00	$1.00
-Insecticides		$0.00	$0.00
-Fertilizer		$5.41	$5.41
-Crop Insurance		$4.00	$4.00
-Custom Work		$0.00	$0.00
-Fuel		$4.00	$4.00
-Lubrication		$0.60	$0.60
-Repairs		$6.76	$6.76
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$4.56	$4.56
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$2.24	$2.24
TOTAL DIRECT COSTS		$39.49	$39.49
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$111.54	$70.99
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$52.27	$52.27
-Over Direct and Fixed Costs		($19.78)	$20.77
* COSTS ON A PER BUSHEL BASIS *			
-Direct Costs		$0.87	$0.87
-Indirect (Fixed) Costs		$1.58	$0.69
-Direct and Indirect Costs		$2.45	$1.56

CROP BUDGET SUMMARY FOR CORN GRAIN
recropped

			ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME				
-Sale of Crop	64	Mkt. Yld. Goal	$124.16	$124.16
-ASCS Def. Pmt.	50.9	ASCS YLD	$7.64	$7.64
GROSS INCOME			$131.80	$131.80
* RESOURCE COMMITMENT *				
DIRECT COSTS ON	86.4	(bu/ac)		
-Seed			$18.05	$18.05
-Herbicides			$16.60	$16.60
-Fungicides			$0.00	$0.00
-Insecticides			$0.00	$0.00
-Fertilizer			$9.08	$9.08
-Crop Insurance			$8.00	$8.00
-Custom Work			$0.00	$0.00
-Fuel			$6.29	$6.29
-Lubrication			$0.94	$0.94
-Repairs			$9.56	$9.56
-Machinery/Tractor Rental			$0.00	$0.00
-Drying			$6.40	$6.40
-Hauling			$6.40	$6.40
-Hired labor (machine time + 10%)			$0.00	$0.00
-Interest on Operating:		6 MONTHS	$4.88	$4.88
TOTAL DIRECT COSTS			$86.21	$86.21
INDIRECT (FIXED) COSTS				
-Cash Rent			$31.50	$31.50
-Tractor Investment			$4.30	------NA-----
-Self Propelled Imp. Investment			$4.37	------NA-----
-Pulled Implement Investment			$4.54	------NA-----
-Depreciation on machinery			$27.33	------NA-----
TOTAL INDIRECT COSTS			$72.04	$31.50
TOTAL ALL COSTS			$158.26	$117.71
RETURN (TO UNPAID OP. LABOR + MGMT)				
-Over Direct Costs			$45.58	$45.58
-Over Direct and Fixed Costs			($26.46)	$14.08
* COSTS ON A PER UNIT BASIS *				
-Direct Costs			$1.35	$1.35
-Indirect (Fixed) Costs			$1.13	$0.49
-Direct and Indirect Costs			$2.47	$1.84

CROP BUDGET SUMMARY FOR CRAMBE
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	10.14 Mkt. Yld. Goal	$96.33	$96.33
-ASCS Def. Pmt.	0 ASCS YLD	$0.00	$0.00
GROSS INCOME		$96.33	$96.33
	* RESOURCE COMMITMENT *		
DIRECT COSTS ON	13.69 HDWT./ACRE		
-Seed		$4.68	$4.68
-Herbicides		$6.83	$6.83
-Fungicides		$0.00	$0.00
-Insecticides		$0.00	$0.00
-Fertilizer		$3.06	$3.06
-Crop Insurance		$4.00	$4.00
-Custom Work		$0.00	$0.00
-Fuel		$4.22	$4.22
-Lubrication		$0.63	$0.63
-Repairs		$7.31	$7.31
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$5.58	$5.58
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$2.18	$2.18
TOTAL DIRECT COSTS		$38.48	$38.48
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$110.53	$69.98
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$57.85	$57.85
-Over Direct and Fixed Costs		($14.20)	$26.35
* COSTS ON A PER BUSHEL BASIS *			
-Direct Costs		$3.80	$3.80
-Indirect (Fixed) Costs		$7.10	$3.11
-Direct and Indirect Costs		$10.90	$6.90

CROP BUDGET SUMMARY FOR SUMMERFALLOW
Acreage Reduction Program acres

	ECONOMIC COSTS/AC	CASH COSTS PER ACRE
* RESOURCE COMMITMENT *		
DIRECT COSTS ON 0 BUSHELS/ACRE		
-Seed	$0.62	$0.62
-Herbicides	$0.00	$0.00
-Fungicides	$0.00	$0.00
-Insecticides	$0.00	$0.00
-Fertilizer	$0.00	$0.00
-Crop Insurance	$0.00	$0.00
-Custom Work	$0.00	$0.00
-Fuel	$3.48	$3.48
-Lubrication	$0.52	$0.52
-Repairs	$3.40	$3.40
-Machinery/Tractor Rental	$0.00	$0.00
-Drying	$0.00	$0.00
-Hauling	$0.00	$0.00
-Hired labor (machine time + 10%)	$0.00	$0.00
-Interest on Operating: 6 MONTHS	$0.48	$0.48
TOTAL DIRECT COSTS	$8.50	$8.50
INDIRECT (FIXED) COSTS		
-Cash Rent	$31.50	$31.50
-Tractor Investment	$4.30	------NA-----
-Self Propelled Imp. Investment	$4.37	------NA-----
-Pulled Implement Investment	$4.54	------NA-----
-Depreciation on machinery	$27.33	------NA-----
TOTAL INDIRECT COSTS	$72.04	$31.50
TOTAL ALL COSTS	$80.54	$40.00
RETURN (TO UNPAID OP. LABOR + MGMT)		
-Over Direct Costs	($8.50)	($8.50)
-Over Direct and Fixed Costs	($80.54)	($40.00)

CROP BUDGET SUMMARY FOR FLAX
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	13.3 Mkt. Yld. Goal	$64.37	$64.37
-ASCS Def. Pmt.	0 ASCS YLD	$0.00	$0.00
GROSS INCOME		$64.37	$64.37
* RESOURCE COMMITMENT *			
DIRECT COSTS ON	18 BUSHELS/ACRE		
-Seed		$5.60	$5.60
-Herbicides		$6.83	$6.83
-Fungicides		$0.00	$0.00
-Insecticides		$0.00	$0.00
-Fertilizer		$2.26	$2.26
-Crop Insurance		$4.00	$4.00
-Custom Work		$0.00	$0.00
-Fuel		$4.40	$4.40
-Lubrication		$0.66	$0.66
-Repairs		$7.48	$7.48
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$1.33	$1.33
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$1.96	$1.96
TOTAL DIRECT COSTS		$34.51	$34.51
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$106.56	$66.01
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$29.86	$29.86
-Over Direct and Fixed Costs		($42.18)	($1.64)
* COSTS ON A PER BUSHEL BASIS *			
-Direct Costs		$2.59	$2.59
-Indirect (Fixed) Costs		$5.42	$2.37
-Direct and Indirect Costs		$8.01	$4.96

CROP BUDGET SUMMARY FOR OATS
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	53 Mkt. Yld. Goal	$65.19	$65.19
-ASCS Def. Pmt.	49.6 ASCS YLD	$0.00	$0.00
GROSS INCOME		$65.19	$65.19
* RESOURCE COMMITMENT *			
DIRECT COSTS ON	71.55 BUSHELS/ACRE		
-Seed		$5.00	$5.00
-Herbicides		$4.77	$4.77
-Fungicides		$0.95	$0.95
-Insecticides		$0.00	$0.00
-Fertilizer		$5.75	$5.75
-Crop Insurance		$4.00	$4.00
-Custom Work		$0.00	$0.00
-Fuel		$4.40	$4.40
-Lubrication		$0.66	$0.66
-Repairs		$7.48	$7.48
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$5.30	$5.30
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$2.30	$2.30
TOTAL DIRECT COSTS		$40.61	$40.61
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$112.65	$72.11
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$24.58	$24.58
-Over Direct and Fixed Costs		($47.46)	($6.92)
* COSTS ON A PER BUSHEL BASIS *			
-Direct Costs		$0.77	$0.77
-Indirect (Fixed) Costs		$1.36	$0.59
-Direct and Indirect Costs		$2.13	$1.36

CROP BUDGET SUMMARY FOR OIL SUNFLOWER
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	12.1 Mkt. Yld. Goal	$105.27	$105.27
-ASCS Def. Pmt.	0 ASCS YLD	$0.00	$0.00
GROSS INCOME		$105.27	$105.27
* RESOURCE COMMITMENT *			
DIRECT COSTS ON	16.35 HDWT./ACRE		
-Seed		$13.20	$13.20
-Herbicides		$9.10	$9.10
-Fungicides		$0.00	$0.00
-Insecticides		$3.30	$3.30
-Fertilizer		$3.89	$3.89
-Crop Insurance		$5.00	$5.00
-Custom Work		$0.00	$0.00
-Fuel		$4.63	$4.63
-Lubrication		$0.69	$0.69
-Repairs		$8.27	$8.27
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$1.21	$1.21
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$2.96	$2.96
TOTAL DIRECT COSTS		$52.25	$52.25
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$124.30	$83.75
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$53.02	$53.02
-Over Direct and Fixed Costs		($19.03)	$21.52
* COSTS ON A PER UNIT BASIS *			
-Direct Costs		$4.32	$4.32
-Indirect (Fixed) Costs		$5.95	$2.60
-Direct and Indirect Costs		$10.27	$6.92

CROP BUDGET SUMMARY FOR SPRING WHEAT
recropped

		ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME			
-Sale of Crop	29.5 Mkt. Yld. Goal	$83.19	$83.19
-ASCS Def. Pmt.	29.8 ASCS YLD	$29.80	$29.80
GROSS INCOME		$112.99	$112.99
	* RESOURCE COMMITMENT *		
DIRECT COSTS ON	39.83 BUSHELS/ACRE		
-Seed		$5.63	$5.63
-Herbicides		$5.68	$5.68
-Fungicides		$1.00	$1.00
-Insecticides		$0.00	$0.00
-Fertilizer		$7.06	$7.06
-Crop Insurance		$4.00	$4.00
-Custom Work		$0.00	$0.00
-Fuel		$4.40	$4.40
-Lubrication		$0.66	$0.66
-Repairs		$7.48	$7.48
-Machinery/Tractor Rental		$0.00	$0.00
-Drying		$0.00	$0.00
-Hauling		$2.95	$2.95
-Hired labor (machine time + 10%)		$0.00	$0.00
-Interest on Operating:	6 MONTHS	$2.33	$2.33
TOTAL DIRECT COSTS		$41.18	$41.18
INDIRECT (FIXED) COSTS			
-Cash Rent		$31.50	$31.50
-Tractor Investment		$4.30	------NA-----
-Self Propelled Imp. Investment		$4.37	------NA-----
-Pulled Implement Investment		$4.54	------NA-----
-Depreciation on machinery		$27.33	------NA-----
TOTAL INDIRECT COSTS		$72.04	$31.50
TOTAL ALL COSTS		$113.23	$72.68
RETURN (TO UNPAID OP. LABOR + MGMT)			
-Over Direct Costs		$71.81	$71.81
-Over Direct and Fixed Costs		($0.24)	$40.31
* COSTS ON A PER BUSHEL BASIS *			
-Direct Costs		$1.40	$1.40
-Indirect (Fixed) Costs		$2.44	$1.07
-Direct and Indirect Costs		$3.84	$2.46

CROP BUDGET SUMMARY FOR SPRING WHEAT
fallow

			ECONOMIC COSTS/AC	CASH COSTS PER ACRE
INCOME				
-Sale of Crop	33	Mkt. Yld. Goal	$93.06	$93.06
-ASCS Def. Pmt.	29.8	ASCS YLD	$29.80	$29.80
GROSS INCOME			$122.86	$122.86
* RESOURCE COMMITMENT *				
DIRECT COSTS ON	44.55	BUSHELS/ACRE		
-Seed			$5.63	$5.63
-Herbicides			$5.68	$5.68
-Fungicides			$1.00	$1.00
-Insecticides			$0.00	$0.00
-Fertilizer			$5.15	$5.15
-Crop Insurance			$4.00	$4.00
-Custom Work			$0.00	$0.00
-Fuel			$4.40	$4.40
-Lubrication			$0.66	$0.66
-Repairs			$7.48	$7.48
-Machinery/Tractor Rental			$0.00	$0.00
-Drying			$0.00	$0.00
-Hauling			$3.30	$3.30
-Hired labor (machine time + 10%)			$0.00	$0.00
-Interest on Operating:		6 MONTHS	$2.24	$2.24
TOTAL DIRECT COSTS			$39.53	$39.53
INDIRECT (FIXED) COSTS				
-Cash Rent			$31.50	$31.50
-Tractor Investment			$4.30	------NA-----
-Self Propelled Imp. Investment			$4.37	------NA-----
-Pulled Implement Investment			$4.54	------NA-----
-Depreciation on machinery			$27.33	------NA-----
TOTAL INDIRECT COSTS			$72.04	$31.50
TOTAL ALL COSTS			$111.58	$71.03
RETURN (TO UNPAID OP. LABOR + MGMT)				
-Over Direct Costs			$83.33	$83.33
-Over Direct and Fixed Costs			$11.28	$51.83
* COSTS ON A PER BUSHEL BASIS *				
-Direct Costs			$1.20	$1.20
-Indirect (Fixed) Costs			$2.18	$0.95
-Direct and Indirect Costs			$3.38	$2.15

APPENDIX B
CROP PRICES AND YIELDS, FOSTER COUNTY, NORTH DAKOTA, 1991

APPENDIX TABLE B1. FOSTER COUNTY CROP YIELDS PER HARVESTED ACRE, 1981-1990

Year	Spring Wheat bu.	Spring Wheat bu.	Barley bu.	Flax bu.	Corn bu.	Oats bu.	Oil Sunflower lbs.	Crambe [a] lbs.
	fallow	----------	----------	----------	recropped	----------	----------	----------
1990	51.3	46.3	67.9	23.0	68.9	74.5	1320.0	1724.0
1989	22.9	19.1	29.1	6.5	59.3	32.0	1210.0	1040.0
1988	16.9	12.2	17.4	5.0	53.6	23.0	1050.0	1290.0
1987	31.2	29.7	46.7	16.0	84.4	56.0	1310.0	
1986	33.8	30.6	51.9	18.0	80.1	63.5	1370.0	
1985	39.0	32.7	50.4	11.4	36.0	55.0	1110.0	
1984	37.0	34.5	52.9	13.0	60.0	54.0	1130.0	
1983	29.5	26.7	39.3	11.0	64.0	56.0	1070.0	
1982	34.2	32.6	50.3	15.0	49.8	57.9	1270.0	
1981	33.8	30.7	50.1	14.0	84.1	58.4	1270.0	
Avg.	33.0	29.5	45.6	13.3	64.0	53.0	1211.0	1351.3
Model Farm	33.0	29.5	45.6	13.3	64.0	53.0	1211.0	1013.5 [b]

[a] Carrington Research Extension Center yield for 'Meyer' crambe.
[b] Seventy-five percent of average yield, based on typical relationship to county average yields to experiment station yields.
SOURCE: North Dakota Agricultural Statistical Service. 1991

APPENDIX TABLE B2. MARKETING YEAR AVERAGE PRICES, NORTH DAKOTA, 1986, 1987, 1989, 1990.

year	Spring Wheat	All Barley	Flax	Corn	Oats	Oil Sunflower	Crambe [a]
	----------	$/bushel	----------	----------	----------	------$/cwt------	
1990	2.45	1.85	5.25	2.20	0.93	10.10	9.50
1989	3.50	2.15	7.25	2.24	1.20	9.80	
1987	2.80	1.70	3.39	1.91	1.57	8.25	
1986	2.52	1.37	3.45	1.42	1.20	6.66	
Average	2.82	1.77	4.84	1.94	1.23	8.70	9.50

[a] Delivered contract price paid to crambe growers in 1990 by National Sun Industry.
SOURCE: North Dakota Agricultural Statistical Service. 1991

APPENDIX C
MACHINERY COMPLEMENT, MODEL FARM, FOSTER COUNTY, NORTH DAKOTA, 1991

APPENDIX TABLE C1. MODEL FARM MACHINERY COMPLEMENT, FUEL USE, PURCHASE AND LIST PRICE, 1991

Implement type	Fuel use (G/HR)	Size (FT)	Purchase price	List price
225 H.P. 4-WD Tractor	13.5	-	$53,813	$71,750
140 H.P. 2-WD Tractor	8.4	-	$35,888	$47,850
75 H.P. 2-WD Tractor	4.5	-	$16,913	$22,550
Large Combine	8.7	-	$72,968	$97,290
Row crop header	-	20	$15,019	$20,565
Grain pickup header	-	13	$ 5,542	$ 7,390
Spray Coupe	4.0	50	$12,285	$17,535
Self-Propelled Swather	3.0	20	$17,580	$23,440
Grain Drill	-	30	$27,653	$36,870
Row Crop Planter	-	20	$12,904	$17,205
Moldboard Plow	-	15	$13,673	$18,230
Chisel Plow	-	24	$ 7,069	$ 9,525
Field Cultivator	-	37	$ 7,778	$10,370
Tandem Disk	-	28	$14,550	$19,400
Springtooth Harrow	-	48	$ 2,025	$ 2,700
Row Crop Cultivator	-	20	$ 3,169	$ 4,225
Rock Picker	-	9	$ 8,550	$11,400

Source: Olson and Hughes, 1991.