Crambe Production

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Crambe (*Crambe abyssinicia* Hochst.) is also referred to as Abyssinan mustard, Abyssinian kale, colewart, or katran. It is a member of the mustard (Cruciferae) family, which includes crops such as rapeseed (canola and industrial oilseed rape) and tame mustard. Crambe is native to the Mediterranean region. It was first introduced into the United States during the 1940s and has been intermittently grown at North Dakota research centers since 1958. Commercial production of crambe in North Dakota began in 1990.

Crambe seed yields an industrial oil which contains a high level of erucic acid. Renewed interest in specialty crops has stimulated research and commercial production of crambe in North Dakota. Commercial production of crambe in North Dakota was contracted on 2,400 acres in 1990, 4,500 acres in 1991, 21,000 acres in 1992, and 56,500 acres in 1993. Inputs and management practices similar to small grains and its unique use as a nonfood crop makes crambe a profitable alternative enterprise for North Dakota farmers.

Crambe may be grown by farmers who participate in USDA farm programs. For example, in 1993 crambe could be grown on flex acres, idled acres under the 0/92 program for wheat and feed grain, and on non-program crop acres. Contact the local ASCS-USDA office for information on the current farm program policies regarding crambe.

Description

Crambe is an erect annual herb with large pinnately-lobed leaves approximately 4 inches long and 3 inches wide. Leaf petioles are about 8 inches long, channeled, and hairy. Plant heights typically vary between 24 and 40 inches depending on the season and plant density. The crop exhibits an indeterminate flowering habit and may continue to set seed in late season. The flowers are white, numerous, and small. The round seeds are borne singly and are about 1/8 inch in diameter. Each seed is enclosed in a hull or pod which usually remains on the seed after harvest. The hulls are typically light brown in color.

Adaptation

Crambe is a cool-season crop that is well adapted to environmental conditions in North Dakota. Crambe requires an average of 54 days (range of 42 to 64 days) between planting and flowering. The flowering period usually ends about 12 to 15 days before physiological maturity. Present cultivars of crambe require between 83 and 106 days from date of planting to reach physiological maturity. Crambe is well adapted to fertile well-drained soils with a pH of 6.0 to 7.5. When crambe is grown on soil with poor internal drainage, good surface drainage is essential. Crambe seed is moderately tolerant to saline

soils during germination over a range of soil temperatures of 50 to 86 degrees F. As soil temperatures decrease below 50 degrees F in saline soils, crambe seed germination rate decreases. Established crambe plants are similar to wheat in saline soil tolerance.

Crambe is best suited to silt-loam soils that do not crust. Soils that have potential for crusting problems need to be managed carefully to prevent emergence problems. If a harrow or rotary hoe is used to break up soil crusting, crambe stands can be reduced if the seedling hypocotyl arch is immediately below the soil surface or the seedlings have emerged. Use of an empty press drill across a crusted soil has been successful in breaking the crust and minimizing crambe stand losses.

While crambe requires adequate soil moisture for flowering, podset and filling, a dry period as the plant approaches maturity is beneficial. Crambe's tolerance to drought conditions is equal to or slightly less than small grains. It is more drought tolerant than corn, canola, mustard, or soybean at all stages of growth.

Rotations

Rotation of crambe with other crops is recommended to avoid a buildup of insects, diseases, and weeds. In crop rotation, crambe should not succeed itself or closely related crops such as canola or mustard. Crambe should follow small grains, corn, grain legumes, or fallow. These crop options provide a break in pest cycles and provide soil conditions that can be easily managed to prepare for crambe production. Crambe also is suitable as a companion crop for alfalfa or other biennial or perennial forage-type legume establishment.

Small grains should perform well following crambe. Crambe stubble provides an acceptable cover for trapping snow, controlling erosion and establishing fall-seeded crops in a no-till production system. When planting fall-seeded crops, care must be taken to minimize stubble disturbance as crambe residue is brittle and easily destroyed. Also, volunteer crambe is easily managed in succeeding crops using tillage and/or herbicides.

Varieties

Meyer, BelAnn and BelEnzian are crambe varieties available for commercial production. Agronomic characteristics and seed yield of several crambe varieties tested at research sites across North Dakota are listed in Tables 1 and 2. Statewide crambe yields have averaged about 1,200 pounds per acre during 1990 to 1993. Yield on individual fields has ranged from 300 to 2,500 pounds per acre during this same period.

North Dakota State University began a crambe breeding program in 1991 utilizing germplasm from the North Central Plant Introduction Center and New Mexico State University, so additional varieties will be developed for production in North Dakota and the Midwest.

Table 1. Agronomic characteristics of crambe trials, North Dakota.*

	1992-93			
Variety	Plant Height	Planting to First Flower	Planting to Maturity	Test Weight	Oil
	(in.)	(days)	(days)	(lb/bu.)	(%)
BelAnn	46	57	100	33	29.9
BelEnzian	45	57	99	33	29.7
Meyer	42	55	99	33	31.2

*Plant height from Williston, Minot and Langdon. Planting to first flower from Minot, Carrington, Prosper and Langdon. Planting to maturity from Carrington. Test weight from Williston, Hettinger, Minot, Carrington, Prosper and Langdon. Oil from Hettinger and Langdon.

Table 2. Crambe variety seed yield trials, North Dakota.

	Grain Yield					
	Williston		Hettinger		Minot	
Variety	1993	4 year	1993	4 year	1993	4 year
	pounds/acre					
BelAnn	2870	1216	2575	1658	3314	2138
BelEnzian	2975	1920	2421	1566	2968	2119

Meyer	2363	1744	1877	1224	2600	2083

	Grain Yield					
	Carrington		Prosper		Langdon	
Variety	1993	4 year	1993	4 year	1993	4 year
	pounds/acre					
BelAnn	1521	1538	1315	1777	1229	1767
BelEnzian	1202	1498	1322	1748	1033	1802
Meyer	1408	1549	1502	1726	1235	1733

Seedbed Preparation and Planting

A critical phase of successful crambe production is stand establishment. A vigorous stand that emerges early will take advantage of cooler temperatures and available soil moisture and be more competitive with weeds. The seedbed for crambe should be firm in order to place seed at a uniform and shallow depth. Seedlings are easily damaged by drifting soil. The seedbed should be prepared to avoid wind erosion. Crambe should be sown ½-inch deep and no deeper than 1.5 inches.

Crambe should be sown in late April to early May when the greatest risk of frost has passed. The seedling crop can tolerate temperatures in the low 20s for several hours. If the crop is injured by frost, allow sufficient time (one to two weeks) to determine if damage warrants destruction of the crop. A significant decrease in seed yield and oil content can be expected if seeding is delayed until late May or June.

Small grain seeding equipment, including double disc opener press drills and air seeders, can be used to seed crambe. However, uniform stand establishment may be more difficult with air seeders. Successful yields have been obtained with row widths ranging from 6 to 36 inches. However, row widths of 6 or 7 inches generally give the highest yields.

A crambe seeding rate of 15 to 20 pounds live seed per acre is recommended. At 60,000 to 80,000 seeds per pound, this seeding rate should provide a targeted stand of 1 million plants per acre or 23 plants per square foot. Seeding rates as low as 8 pounds live seed per acre have resulted in low plant densities (10 to 12 plants per square foot) but good yields due to increased plant branching and an extended flowering period. However, using the recommended seeding rate will result in crambe plants being more competitive with weeds and maturing more uniformly. The recommended seeding rate also is suggested if soil crusting is anticipated. Seeding rates greater than 20 pounds per acre will result in greater seed costs, earlier maturity, less plant branching, increased lodging, and possibly lower yield compared to the recommended seeding rates.

The laboratory procedures currently being used for standard germination have yet to provide a consistent estimate of crambe seed viability. For example, crambe seedlots with a standard germination of 70 percent have performed similarly in the field to seedlots with 90 percent germination or greater. Until improved testing procedures are developed, it does not seem necessary to discount seedlots (and increase seeding rates) based upon their standard germination test alone.

Fertility Management

Crambe's response to soil fertility is similar to that of small grains, mustard and canola. A soil test should be conducted to determine the need for primary nutrients. About 5 pounds of nitrogen is required for each 100 pounds of seed yield per acre. Avoid using more than 10 pounds of actual nitrogen with the seed as germination injury can occur. Crambe is responsive to phosphorus fertilization rates of 25 to 50 pounds per acre. Refer to NDSU Extension Service circular SF-718, "Fertilizing Mustard, Rapeseed, Canola and Crambe," for additional information that relates to crambe nutrition needs.

Weed Control

Weed control is a critical management factor in crambe production. The crop is not a strong competitor with weeds during early vegetative development. Typically, three to four weeks is required for a 100 percent crop canopy to be formed after emergence. It is during this period that the biggest challenge for weed control exists.

It is important that crambe be seeded on relatively weed-free fields. Fields that contain perennial weeds such as Canada thistle, perennial sowthistle, field bindweed and quackgrass should be avoided. Also, avoid fields where crops grown the previous year may produce volunteer plants such as buckwheat, corn, and sunflower. A vigorous stand should be established ahead of weed development to provide optimum competition. Seeding early and using recommended seeding techniques will help establish a crambe stand that is competitive with weeds.

Treflan is labeled for fall or spring application as a preplant, soil-incorporated treatment to control annual grass (e.g. foxtail species) and certain broadleaf weeds in crambe. See Table 3 for Treflan rates.

Table 3. Treflan* broadcast application rates per acre.

Soil Texture	Treflan or Treflan M.T.F.	Treflan 5	Treflan TR-10
	pints	pints	pounds
Coarse	1.0	0.8	5.0
Medium	1.5	1.2	7.5
Fine	2.0	1.6	10.0

*DowElanco. 1993. Treflan supplemental labeling. Indianapolis, IN 56285.

A harrow or rotary hoe may be used for weed control three to seven days after crambe planting or after the crop has emerged. However, extreme caution must be exercised with these tillage tools as a high percentage of crambe seedlings may be damaged or destroyed.

Crambe is susceptible to damage from drift of many broadleaf herbicides, certain soil-applied herbicides and certain herbicide residues. Refer to the NDSU Extension Service circular W-253, "Agricultural Weed Control Guide," for additional crambe weed control information.

Diseases

Few disease problems associated with crambe have been observed in North Dakota. Crambe is susceptible to sclerotinia (white mold), but less so than sunflower and dry bean. However, if excessive moisture is present during flowering, sclerotinia infection and seed yield loss may be high. Excessive moisture conditions throughout the 1993 growing season in North Dakota resulted in significant yield loss due to sclerotinia and alternaria. Other potential diseases include blackleg and pythium root rot.

Carefully plan crop rotations to keep disease pressure to a minimum. It is suggested to maintain a four-year rotation with crambe as well as other crops susceptible to sclerotinia such as canola, dry bean, mustard, soybean, and sunflower. Seed treatment is generally not required on high quality crambe seed. Use seed from disease-free fields, excluding areas where blackleg or alternaria were present.

Insects

Insects that have potential for causing economic damage to crambe include aphids, cabbage maggots, grasshoppers, diamondback moth, leafhoppers and lygus bugs. Of these, only grasshoppers have caused significant injury to crambe (typically in field margins). Crambe is most susceptible to grasshopper damage at the seedling stage. Grasshoppers tend to choose other crop foliage as crambe develops.

Harvesting

After flowering, crambe matures rapidly (one to two weeks). Timely harvest is important to avoid high shattering losses. During warm dry weather the crop should be frequently monitored (daily or every other day) to determine correct harvest stage.

Crambe is physiologically mature when 50 percent of the seeds have turned brown. At maturity, the appearance of the plant may vary from leaves turning yellow and dropping to the plant (stems and leaves) remaining green. Attention should be directed to the seeds and seed-bearing branches to determine the onset of harvest.

Crambe may be swathed or straight cut. Both harvest methods have been successful, but the choice depends on acreage, harvest equipment, weather conditions, uniformity of maturity, and weed density. Straight combining is recommended for a mature, clean and low moisture crop. If the majority of seed pods are brown, straight combining is recommended as swathing may cause excessive shattering. If approximately 100 crambe seeds per square foot are present on the ground from shattering, a 60-pound-per-acre yield loss occurs. Crambe seed moisture should be 14 percent or less for straight combining. Crambe seed containing greater than 14 percent moisture will cause harvest problems due to difficulty moving

the green plant material through the combine. At seed moisture less than 12 percent, high shattering potential exists.

Swathing may be necessary if maturity is variable where some plants are beginning to shatter, while others are still slightly green. If a sufficient number of green weeds are present, swathing may be required. Crambe should be swathed when at least 50 percent of the seeds have turned brown. If the majority of the seed turns brown before swathing, the swathing and combining operations may cause excessive shattering. When swathing, reel speed should be reduced to one-half to two-thirds of that for small grains. Seed shatter can be minimized by swathing during a time of day when humidity is high. Swathing should be done just below the lowest seed pods, leaving the stubble as high as possible. This will allow the windrow to settle into the stubble and reduce loss from wind. Crambe will dry quickly after a rain (compared to small grain) in a swath or if the crop is standing.

It is important that the combine be adjusted correctly when harvesting crambe. The first priority should be to harvest as much of the seed as possible with a minimum of seed damage. The seed should be harvested with the hulls intact.

Combine cylinder speed of 400 to 500 rpm is recommended. Concave clearance may range from inch to near wide open, depending on combine type and crop characteristics. Excessive cylinder speed or narrow concave clearance can cause an increase in hulled or split seed. Rarely will hulls be found in the combine hopper because they are normally blown out the back of the combine. Splits can be detected by looking for bright yellow flecks on the ground behind the combine.

Conventional combine fan speed should be set at about 500 rpm, while rotary combines are set at about 600 rpm. Never disconnect the fan to completely shut off the air. It may be necessary to place cardboard over a portion of the air intake to the fan if seed is being blown out the back of the combine at low fan settings. The sieve settings for small grains should be appropriate to begin harvest, followed by adjustments for crambe seed. When straight combining, set the reel to move only slightly faster than the ground speed of the combine. This is essential to reduce seed shattering.

Conditioning and Storage

Crambe seed is small, round, and very light weight (25 pounds per bushel). Because crambe has a low test weight and is a relatively bulky crop, transportation costs are greater than for small grain and corn, but similar to sunflower. Equipment for transportation and facilities for storage must be tight to avoid loss of the seed. Before drying and storage, the seed should be passed through a roller screen or scalper to remove excess foreign material.

Crambe seed should be stored and marketed at a moisture content of 10 percent or less. Calibrations are being developed to determine crambe seed moisture with electronic moisture testers. A tentative conversion chart was developed in 1993 for the Motomco moisture meter. When moisture testing crambe and using oil sunflower standard charts, the moisture tester reading will be about 1 to 2 percentage points low depending on the brand and moisture range.

If seed is harvested at high moisture, natural air or artificial drying can be used. Do not dry seed with unheated air if seed moisture content exceeds 20 percent. To maintain seed quality, a maximum drying temperature of 110 degrees F is recommended. Bin-drying with unheated air requires a minimum airflow of 1 cfm per bushel. During storage, the seed should be checked at regular intervals for heating or other problems. To prevent heating, aerate the seed with a minimum airflow of 0.1 cfm per bushel. Aeration should be continued until seed moisture and temperature equilibrium has been maintained throughout the bin.

Utilization

Primary products from crambe seed produced in North Dakota include oil (28 to 33 percent), meal (64 to 69 percent) and hulls (3 percent).

The oil is a valuable raw material that can be used for numerous industrial products. Oil from crambe seed ranges from 50 to 60 percent erucic acid by weight. Erucic acid is used for slip agents, plasticizers, surfactants, antistats, flotation agents and corrosion inhibitors. Other derivatives from crambe oil can be used for lubricants, rubber additives, new types of nylon, base for paints and coatings, high temperature hydraulic fluids, dielectric fluid, pharmaceutical products, cosmetics, waxes and other products. Also, a high erucic-acid oil derivative called `caprenin' may be used as a low-fat cocoa butter substitute in candy and other foods.

Crambe meal may be used primarily as livestock protein but also can be used for protein isolates and fertilizer. The protein content of defatted, dehulled crambe meal may be as high as 45 percent, but if processed with the hull the protein content drops to about 30 to 32 percent. Seed is normally dehulled (during processing) to produce a higher protein, lower fiber meal. Crambe meal contains glucosinolates, which are sulfur-containing substances. Single stomached animals such as swine and poultry can develop toxicity problems from ingesting glucosinolates, while ruminant animals such as cattle and

sheep exhibit greater tolerance. The Food and Drug Administration has approved use of defatted crambe meal as a beef cattle protein supplement at levels up to 4.2 percent of the total weight of rations.

Marketing

United States and North Dakota markets are limited because of the crop's recent commercialization. Crambe should only be grown under contract. Marketing contracts for crambe are offered by National Sun Industries, which crushes seed near Enderlin. Crambe prices are established through world futures markets for high erucic-acid crops. Expansion of crambe production and processing will lower U.S. dependence on imported petroleum oil and European and Canadian sources of oil from high erucic acid crops.

Economics

Table 4 includes an estimated 1993 crambe production budget for south central North Dakota. The budget provides an estimate of revenue and costs for crambe. The budget is intended to be used as a guide for developing individual crambe budgets. Budget details and crambe budgets for other regions of North Dakota are available from the NDSU Extension Service.

Table 4. Estimated 1993 crambe budget, south central North Dakota.

	Profitability Per Acre*	Cash Flow Per Acre*
Market income**	124.80	124.80
Direct costs		
Seed	4.50	4.50
Herbicides	6.24	6.24
Fungicides	0.00	0.00
Insecticides	0.00	0.00
Fertilizer	8.93	8.93
Crop insurance***	8.45	8.45
Fuel and lubrication	5.76	5.76
Repairs	7.95	7.95
Drying	0.00	0.00
Miscellaneous	1.05	1.05
Operating interest	2.04	2.04
Sum of listed direct costs	44.92	44.92
Indirect (fixed) costs		
Miscellaneous overhead	3.87	2.09
Machinery depreciation	14.79	--
Machinery investment	7.53	15.41
Land taxes	3.29	3.29
Land investment	25.08	9.70
Sum of listed indirect costs	54.57	30.49
Sum of all listed costs	99.49	75.41
Non-program participation:		
Return to labor and management	25.31	--
Net cash flow	--	49.39
Listed costs per budget unit (lb):		
Direct costs	0.03	0.03
Indirect costs	0.04	0.02
Total costs	0.08	0.06

*Assuming market yield of 1,300 lbs. per acre.
**Market price of $0.10 per lb. minus $0.004 per lb. transportation costs assuming 100 miles from market.
***Crop insurance premium for 65% of market yield.
