Influence Of Harvest Management On Seed Quality And Yield Of Crambe

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ABSTRACT
Crambe is a new oilseed crop that yields an oil with a high content of erucic acid. Seed shatter problems have prompted growers to attempt modified harvest procedures that may reduce seed loss. There is a concern that these modified harvest practices may reduce the quantity and quality of oil produced from crambe. A field trial was conducted over a two-year period to determine the impact of windrowing and harvest stage on crambe seed yield and oil quality. Crambe was harvested at four stages of ripening based on percent of seed changing from a green to brown color. Early harvest timings resulted in an ease of windrower operation, compact windrows and limited seed loss. Study results indicate that early harvest stages caused significant reductions in seed weight, oil and erucic acid content. These results suggest that physiological maturity of crambe does not occur until some time between the 50% and 95% brown seed stage. Contrasts between crambe cured in the windrow and dried with heated air were made to determine the amount of dry matter assimilation and oil deposition that occurs while the crop dries to harvest moisture. At early harvest stages, the rapid plant dry-down from heated air caused a reduction in both oil and erucic acid content. These data indicate that significant assimilation of dry matter, oil and erucic acid synthesis continues as plants dry in the windrow. Windrowing crambe at earlier timings may reduce seed shatter. Timing the harvest operation after 50% brown seed stage is necessary to obtain high quality crambe seed.

INTRODUCTION
Crambe (*Crambe abyssinica*) is a new oilseed crop that has been commercially grown in the northern Great Plains since 1990. The land devoted to production of crambe in this region has significantly increased from 900 hectares in 1990 to more than 20,000 hectares projected for 1998. Crambe yields high levels of erucic acid, a fatty acid with 22-carbons and an isolated double bond. Oils high in erucic acid are desired in industrial applications due to their stability at high temperatures and high degree of lubricity.

Crambe is generally well adapted to the climate and farming practices inherent to the region. Early research identified the potential for seed shatter and related harvest difficulties in crambe production (White and Higgins, 1966). Crambe plants produce an abundance of branches with individual seeds developing on a panicled raceme. As crambe matures the plants and seed turn from a green color to brown color. When plants dry the fine stems holding the seed becomes fragile and prone to breakage and subsequent seed shatter.

The potential for losses from seed shatter was realized in the early 1990's as growers experienced field losses as high as 1100 kg ha-1. Crambe was normally direct combined when the seed approached storage moisture (10%) or windrowed when a majority of the plant had turned brown in color. Growers attempted to reduce seed shatter and shorten the time until harvest by windrowing the crop early when the plant and seed were green. Chemical desiccation at this same stage has also been considered as means to hasten the harvest operation and reduce the potential for shatter.

Early windrowing of crambe may be part of the solution to reduce seed shatter losses. However, the impact that early harvest operations have on crambe seed yield and oil quality (i.e. oil and erucic acid content) are not known. These harvest operations may occur before the time of maximum dry matter accumulation, oil deposition, and erucic acid synthesis. Bauer et al. (1985) identified continued assimilation of dry matter in seeds of spring wheat after windrowing. Work with soybean by Carver et al. (1984) has shown that maximum oil content and final fatty acid profile had not occurred with the loss of chlorophyll in the seed during maturation.

OBJECTIVES
1. *Determine the impact of windrowing crambe at different harvest dates on seed yield, oil and erucic acid content.*
2. *Evaluate the effect of crambe cured in the windrow versus crambe dried with heated air on seed yield, oil and erucic acid content.*

A crambe field in bloom.

MATERIALS AND METHODS
A field experiment was conducted at Carrington, ND during the 1993 and 1994 growing seasons. The crambe cultivar 'Meyer' was planted on a site with a Heimdal loam soil (coarse-loamy, mixed, frigid, Udic Haploborolls) that was cropped to wheat the previous year. The experimental design was a randomized complete block, with a split-split-plot arrangement of treatments with four replications. Planting dates were assigned to main plots; harvest timing to split-plots; and dry-down method to split-split-plots. Planting dates were established around 1 May and 24 May. Harvest timings consisted of windrowing the crop at 5% brown seed (HT1), 50% brown seed (HT2), 95% brown seed (HT3) and direct combine when seed moisture reached 10% (HT4). A windrower with a 4.5 m wide cut was used to establish a windrow 24 m long within each split-plot.

Immediately upon completion of each windrow operation, treatments to impose dry-down methods were established by cutting out 1.5 m long sections of the windrow. Determinations of the curing process that occurs were made by allowing selected windrow sections to naturally dry down to harvest moisture in the field. The second dry-down method was established by collecting sections of the windrow into cloth bags and drying the plants with air heated to 46 C until the seed reached 10% moisture. Drying the plant samples rapidly with heated air gives an indication of seed and oil status at the specific time of cutting.

The current best management practices were utilized to establish and manage the crop. All plant samples were threshed when the seed moisture content reached 10%. Fatty acid profiles based on gas chromatograph technology were used to determine oil quality (FAC-1 from the Canadian Grain Commission). Statistical analysis for all variables was conducted with SAS (SAS Institute Inc., 1996).

RESULTS AND DISCUSSION

HARVEST TIMING
The experience of imposing the harvest timings with the windrower made clear the differences in relative harvest ease due to dry-down stage of the crop. Early timings resulted in a crop that flowed easily through the windrower and resulted in a compact windrow and very minor seed loss. Timing the harvest operation at HT1 or HT2 also hastened the time at which crambe reached 10% seed moisture (data not reported). Windrowing the crop at 95% brown seed stage resulted in difficulty of plant material flow through the equipment, a large windrow prone to movement by wind and obvious seed loss. Planting date did not influence the crop response to harvest management.

The specific time at which crambe was windrowed had a significant impact on seed quality and seed weight . Highest seed weights were attained at HT2 in 1993 and by HT3 in 1994 (Table 1). Harvesting crambe at early harvest stages caused a reduction in both oil content and the partitioning of erucic acid. Results from the two years differ as to when maximum oil deposition occurs. The data would suggest that harvest should be delayed until the HT3 stage or shortly before to obtain the highest oil content. Erucic acid content was greatly influenced by harvest timing. Windrowing crambe prior to the HT3 stage caused significant reductions in erucic acid content. The magnitude of this reduction was especially apparent at the HT1 stage. The data would indicate that crambe did not reach physiological maturity until sometime after the HT2 harvest stage. The reduced seed weights, oil content and erucic acid partitioning associated with the early harvest stages suggest that plant maturity occurs between the 50% and 95% brown seed stage.

Table 1. Crambe seed and oil characteristics as influenced by harvest timing at Carrington, ND, in 1993 and 1994.

Harvest Timing	Seed wt.	Seed yield	Oil content	Erucic acid
	mg seed^{-1}	kg ha^{-1}	g kg^{-1}	g kg^{-1}
1993				
5% Brown seed (HT1)	44.2	1553	276	510
50% Brown seed (HT2)	50.3	1623	304	542
95% Brown seed (HT3)	54.5	1372	325	557
10% Seed moisture (HT4)	53.7	1340	329	556
LSD (.05)	1.6	204	9	11
1994				
5% Brown seed (HT1)	57.4	1618	301	537
50% Brown seed (HT2)	62.1	1798	327	565
95% Brown seed (HT3)	63.6	1658	334	571
10% Seed moisture (HT4)	63.1	1738	342	571
LSD (.05)	1.7	NS	7	2

Seed yield was not impacted by harvest timing in the 1994 trial, however differences existed in 1993 when the highest yields were associated with the HT2 stage of harvest. In 1993, moderate seed loss occurred during the windrow operation at HT3 and HT4. Crambe plants at these stages are typically fragile and optimum climatic conditions and equipment operation are required to prevent high levels of seed shatter. During 1994, humid conditions during the later harvest stages favored seed retention. The ease of harvest associated with the earliest harvest timings along with an absence of seed loss are obvious reasons why growers would prefer to windrow crambe while the seed remains green. However, the reduced levels of total oil and erucic acid content associated with these timings result in a lower quality product. A high level of both total oil and erucic acid are required for crambe to be a competitive commodity within the industrial oil markets of the world.

DRYDOWN METHOD
Whether crambe was allowed to cure in the windrow or was dried to 10% moisture with heated air had a significant impact on crambe oil. Heated air as a dry-down method resulted in both reduced oil and erucic acid content (Table 2). The rapid dry-down of the plant material with this procedure prevented the process of assimilation to continue as evidenced by the results from the natural dry-down method. These data indicate that dry matter deposition, oil and fatty acid synthesis continue to occur in plants even after they have been cut and laid in the windrow.

Table 2. Crambe seed and oil characteristics as influenced by dry-down method at Carrington, ND, in 1993 and 1994.

Drydown method	Seed wt.	Seed yield	Oil content	Erucic acid
	mg seed^{-1}	kg ha^{-1}	g kg^{-1}	g kg^{-1}
1993				
Natural drydown	49.8	1439	315	546
Heated air drydown	51.6	1505	301	536
LSD(.05)	6	NS	3	7
1994				
Natural drydown	61.5	1702	332	567
Heated air drydown	61.7	1704	320	555
LSD(.05)	NS	NS	4	1

RESULTS AND DISCUSSION (cont).
The continued assimilation of dry matter and oil by crambe plants in the windrow was particularly apparent when specific harvest timings are considered. Forcing plants to dry-down rapidly because of the heated air resulted in significant reductions in the oil and erucic acid content at the early harvest timings (Table 3). These differences became less evident as the plants matured. When harvest occurred at HT3 or later the dry-down method had no influence on seed or oil characteristics. If growers choose to windrow crambe when 50% or more of the seed remains green they can expect the seed to continue development as it cures in the windrow. However, if adverse climatic conditions of high temperatures with strong winds combine to dry-down the windrow much more rapidly than normal, assimilation likely will be reduced.

Table 3. Oil and erucic acid content of crambe seed as influenced by harvest timing and dry-down method at Carrington, ND, in 1993 and 1994.

	Oil content		Erucic acid	
	--------------- Dry-down method		---------------	
Harvest timing	Natural	Heat	Natural	Heat
	g kg^{-1}		g kg^{-1}	
1993				
5% Brown seed (HT1)	290	262	524	496
50% Brown seed (HT2)	312	296	548	535
95% Brown seed (HT3)	330	319	555	559
10% Seed moisture (HT4)	329	329	557	556
	LSD(0.05)	6	12	
1994				
5% Brown seed (HT1)	314	289	557	517
50% Brown seed (HT2)	333	320	569	562
95% Brown seed (HT3)	339	329	572	570
10% Seed moisture (HT4)	342	342	571	571
	LSD(0.05)	8	2.5	

SUMMARY
Modification of crambe harvest operations to reduce seed loss through early windrow timings did result in minimum seed shatter, an easily managed windrow and hastened the time at which crambe reached 10% threshing moisture.

Harvest timing had a varied impact on seed yield of crambe. Dry climatic conditions during the later harvest stages favored seed loss and a subsequent reduction in seed yield. Harvesting crambe at early harvest stages caused a reduction in seed weight, oil and erucic acid content. The data show that harvest should be delayed until the HT3 stage or shortly before to obtain the highest oil and erucic acid content. Reductions in oil quality were greatest when windrowing occurred at the HT1 stage. The reduced seed weights, oil content and erucic acid partitioning associated with the early harvest stages suggest that physiological maturity occurs between the 50% and 95% brown seed stage.

Dry-down method had a significant impact on crambe oil. Crambe plants that were dried with heated air resulted in both reduced oil and erucic acid content. Plants that cured gradually in the windrow continued to assimilate significant amounts of dry matter and oil. When plants were harvested after the HT3 stage the dry-down method did not impact seed or oil characteristics. Timing the harvest operation after 50% brown seed stage will be necessary to obtain both high quality oil and seed yield.

Crambe nearing maturity.

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