Camelina Releases
2007

I recommend that camelina varieties MT 0301, MT 0303 and MT0305 be licensed releases under Option "c" of the "Variety Release Policy".

c. License Release: Variety is protected with PVP title V and released as an exclusive (one business) **or** non-exclusive (more than one business) process. Each requires a license agreement with MSU Technology Transfer. MSU Royalty Fees are collected with a license releases and MAES Research Fees are not collected.

Introduction

Camelina is an ancient crop first known to be cultivated in Northern Europe during the Bronze Age. Camelina, *Camelina sativa* L., is native to northern Europe from Finland to Romania and Scandinavia. Camelina fell into disfavor when more productive crops such as wheat and canola began to be produced and camelina became a contaminant in flax. Farm subsidy programs supporting commodity crop further reduced camelina production. It became a common weed in Europe known as false flax (contaminating flax fields) and by its Roman name, Gold-of-Pleasure. Camelina cultivation has been strengthened recently as demand for omega 3 oils and biodiesel have increased. Omega 3s are a highly unsaturated fatty acid with the characterization of an unsaturation at position 3 on the fatty acid. Fatty acids are typically linked together, in either plants or animals, to form "triglycerides"- what we commonly call fats and oils. Both plants and animals manufacture triglycerides. Those at room temperature are solid are called fats, those that are liquid are oils.

Camelina has good agronomic characteristics. It is easily grown, is low in input requirements (water, nutrients, and pesticides) and return on investment by producers is good. Camelina is about 34-36% omega 3 oil. The seeds are small (typically 345,000/lb) but very dense. The oils are high in omega 3 and also in gamma tocopherol (a superior vitamin E), which acts as an antioxidant. Therefore camelina oil is far more shelf stable than most vegetable-based omega 3 oils such as hemp, flax or perilla. The oils of these crops lack the ability to generate the highly valued, long-chain omega 3-type fatty acids: EPA and DHA. However, camelina offers higher-level intermediates, which are more similar to EPA and DHA than other omega 3 vegetable oils and easily metabolized to EPA and DHA. Table 1, however, indicates camelina does contain EPA (20:5n3) and DHA (22:6n3) as intermediate standards were not available.

Camelina is a crop well suited to Montana's varied growing conditions. Cold tolerance is excellent and camelina should be seeded before other spring-planted crops for maximum yield, typically early to mid-March. Typically, data show delays in planting after March 20 result in yield reductions averaging 100 pounds per week of delay. Fertility requirements are nominal with little response to Nitrogen, Phosphorus, Potassium or Sulfur in western Montana trials and similar responses to N, K and S in eastern Montana. Insects have not been a concern in the trials since they began in 2002. No diseases have been observed until 2006 and only under high rainfall conditions typical of the Flathead Valley. Currently, weed control can be accomplished with plant density and no herbicides are registered for use with camelina.

In terms of oil utilization, the oil is about 64% polyunsaturated, 30% monounsaturated, and 6% saturated fat. While this was detrimental to camelina development in the past, today's technologies allow for a wide market potential of the oil and of its components for both food and industrial applications. A fatty acid profile of the cultivar 'Celine' is illustrated in Table 1. Omega 3 fatty acids are indicated by XX:Xn3.

Fatty analysis of the US world collection at MSU-NWARC has shown considerable genetic variation in oil composition even though phenotypic (visual) variation can be nominal. Variations have been found for dates of maturity, yield, seed size, oil content, and disease resistance. Beginning in 2002, camelina research was initiated at Northwestern Agricultural Research Center, Kalispell, MT, to develop camelina as a feedstock for the emerging biodiesel industry and to develop new cultivars with specific yield components suitable to Montana conditions. While common seeding of camelina may involve either broadcasting, broadcasting followed by packing, or by drlling, cultivar selection has been carried out using a small plot drill in all cases. In Kalispell, no differences in seeding system have been observed.

Table 1. Fatty Acid Profile in Montana Camelina cv. Celine (data from Kansas State University, 2003)

Cultivar	C6:0	C8:0	C10:0	C11:0	C12:0	C14:0	C14:1	C15:0	C15:1	C16:0	C16:1	C17:0	C17:1
Celine (% fatty acid)	0.0	0.1	0.0	0.2	0.1	0.7	0.0	0.2	0.0	6.2	0.3	0.3	0.1

C18:0	C18:1n9t	C18:1n11	C18:1n9c	C18:1n7	C18:2n6t	C18:2n6c	CLA1 9c,11t	CLA210t,12c
2.7	0.3	0.0	16	1.2	0.1	20.4	0.3	0.0

CLA3 9c,11c	CLA4 9t,11t	C18:3n6	C18:3n3	C20:0	C20:1	C20:2	C20:3n6	C204n6
0.7	0.3	0.0	32.5	1.5	11.8	1.8	0.0	0.1

C20:5n3	C21:0	C22:0	C22:5n3	C22:6n3	C24:0	C24:1
0.1	0.0	0.5	0.2	0.2	0.2	0.7

Camelina is becoming accepted as an oilseed for use in biodiesel, chemical feedstocks, omega 3-neutraceuticals and for biotechnological modification. In addition to the oil, camelina is rich in vitamin E form: gamma tocopherol (Table 2). Vitamin E can be found in 4 forms: alpha, beta, gamma and delta. The oxidative stability increases in the order: α, β, γ, δ. Therefore, although camelina is very high in omega 3 oil (a very unstable oil), it is also high in gamma tocopherol and has a reasonable shelf life without hydrogenation or special storage conditions.

Table 2: Tocopherol (µg/g)

	Camelina	Flax	Canola
α- Tocopherol	7	38	37
β- Tocopherol	0	0	0
γ- Tocopherol	255	0	66
δ- Tocopherol	4	0	2
Total Vitamin E	266	38	105

Data provided by Great Northern growers, 2005

Prior research in Europe has shown seed size is inversely correlated with oil percentage and no selection for seed size has been made. In 2006 at NWARC, downy mildew was observed for the first time in the yield, seeding date and fertility research plots. The 2006 spring was unusually wet and cool and these conditions may have contributed to the spread of the disease. In addition, two Ukrainian lines were introduced and showed symptoms very early and very intensely, indicating they may have carried downy mildew with them fro m Europe. All selections proposed are equally susceptible to downy mildew.

All yield plots at NWARC were seeded no later than March 20 at any given year. Beginning in 2004, trials at other research centers and off-station trials were initially seeded in late April to May when canola was seeded. Yield depression due to late planting was evident across all eastern Montana locations. By 2005, earlier seeding was generally used and yields correspondingly increased. Much like the date-of-planting induced yield depression, yields were assumed to be limited by rainfall. The assumption was yields could be calculated as 100 pounds of seed per inch of rain. That has been shown to be untrue as yields of 1,800 pounds have been obtained on less than 10 inches of rainfall in north central Montana.

Selections were based upon single plant selections from the USDA world collection grown in 2002. Of the 135 plant introductions (PI) in the collection, 12 were screened for specific phenotypic characteristics and 6-10 plants selected from each of those 12. These populations were grown as single, unreplicated plots in 2003. In 2004, replicated plots were spring planted and selections were made based upon agronomic seed yield and fatty acid composition. In 2005, seed was sent to Bozeman, MT for organoleptic analysis (tasting) and one line selected as very bland in flavor.

General production practices

Camelina developed under the climatically rigorous climates of sub-arctic Europe. Yield has been found to be related to planting date and moisture availability. Camelina is highly adapted to cold soil germination with minimal moisture. This ability to grow at low temperatures has provided producers with the ability to seed earlier than most seed, taking advantage of stored winter moisture and maturation prior to the onset of heat and drying winds. An example of this can be seen in Table 2 as relates to planting date. While many research centers have grown camelina, in general they like the growers have tried to plant typically when canolas are planted after frost. Consequently, their data will be presented but does not represent the agronomic potential of this crop and data from Northern Ag Research Center (NARC) and Northwestern Ag Research Center (NWARC) will be used for release justification. In general, 2003-2006 trials at NWARC have shown yield potential declines by 105 lbs/acre per week of planting delay after March 20. Significantly greater loss appears to occur in the Northern High Plains as illustrated by data from NARC (Table 3).

Table 3. Yield response to date of planting, NARC and NWARC: cv. "Celine"

Location- Planting Date	Yield lbs/acre
NARC-Havre- March 3, 2005	1635.7**
NARC-Havre- May 5, 2005	714.6
NWARC-Creston- March 10, 2004	2007.1*
NWARC-Creston- April 20, 2004	1457.3
NWARC-Creston- March 20, 2005	2064.4*
NWARC-Creston- April 15, 2005	1438.2

**P=0.001 *P=0.05

Soil fertility has been a concern in camelina. Literature reviews show very little response to NPK. At NWARC, yield increases have typically not been seen at applications above 35 lbs/a N (yield potential of 1600-1800 lbs/acre) or 50 lbs/acre (yield potential >2000 lbs/acre). At NWARC, in three years of testing no response to phosphorus or sulfur has been noted. Some response has been noted by Western Triangle Research Center- Conrad in off station trials.

Insects have not been observed in camelina and no insect damage has been noted. In 2006, downy mildew was observed for the first time at NWARC and in Flathead off station nurseries. No significant resistance was observed in the USDA world collection grown at this location. The disease was apparently brought in with Ukranian seed as only nurseries where Ukranian seed was planted were affected. In drier climates east of the Continental Divide, no disease has been observed in the three years of ongoing trials at the five research centers.

In all trials, seeding rates of 2.5 to 3 lbs/acre were used. Trials at NWARC and NARC in 2003, 2004 and 2005 have shown no significant difference in yields at seeding rates of 2.5 to 6 lbs/acre. Lower seeding rates were used to simulate production practices recommended to growers.

In development, thirty-two germplasm sources provided by USDA were grown as small plots in 2003. Single plants within each source were selected based upon agronomic characteristics for potential development of a camelina-based biodiesel industry. One hundred and 20 plants were selected and plant-rows were field planted in 2004 in replicated plots at NWARC. No phenotypic variation was observed within plots and further selection of the three lines was based upon maturity, lodging, test weight, and seed yield. The three selections made in 2004 were distributed for immediate evaluation by MSU research centers.

For Variety Release

Three Montana selections are proposed for release in 2007:

1. Montana 0301 (scripted MT01 in trials): a short season, high yield line particularly adapted to high yield environments. MT01 is also high in Omega 3 and precursors for DPA long chain omega 3 fatty acids.

2. Montana 0303 (scripted MT03 in trials): a mid-season, highly yield stabile line. MT03 is average in fatty acid profiles, high in ETA precursors (long chain omega 3 fatty acids) and is designed particularly for use in biodiesel.

3. Montana 0305 (scripted MT05 in trials): a mid-season, average yield line. MT05 is typically 2-3 percent higher in oil content than the other two lines. MT0305 is high in α-linolenic acid (C18:3n3).

Each of these lines have specific characteristics of value to an emerging biodiesel industry and potentially to a developing nutraceutical omega 3 oil industry.

Montana 0301

MT0301 was selected from P.I. 304269 (Sweden) as a single plant selection from an increase block in 2003. MT0301 was observed to be significantly earlier in maturity and higher in yield than the related plants in the P.I. 304269 plot and earlier than any of the 32 USDA plant introductions in the trial. MT0301 was increased as a plant-row in 2004 and entered into replicated trials in 2005 and 2006 at nine MAES stations. General data tables are attached as appendices. The cultivar, “Celine” is used as the control in all studies. Celine is a high omega 3 camelina variety developed in France.

MT0301 has several values of merit:

1. While all three lines exceed the yield of the control (Table 4, MT0301 has shown the greatest response in “high yield environments” (Creston, Havre and Bigfork). This can be illustrated by its low yield stability analysis (b=1.29) compared to Celine which was not as responsive to environment and performed better under stress environments (Knees, Denton).
2. Testweight for MT0301 were similar to the other MT lines but the higher test weight is related to the smaller seed size of MT0301.
3. Bloom date and maturity date for MT0301 were significantly earlier for MT0301 which is potentially useful in stressful environments.
4. Shatter was significantly decreased in MT0301, possible because of its smaller seed size.
5. MT01 was identified as the line highest in long chain omega 3 (Ω- 3) fatty acids and total omega-3s.
6. The general recommendation is that MT0301 be grown in potential high yield environments where moisture and soil fertility are less limiting on maximum yields.

Table 4. Yield trial characterization: Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad*

	Yield lbs/acre	Test wt lbs/bu	Plant Ht inches	Bloom date (julian)	Shatter % at ripe	Oil % of seed	Ω- 3 oil %
Celine	1295.9 B	50.24 B	35.72 C	154.60 C	3.47 C	34.6 C	33.5
MT01	1348.3 A	51.12 A	33.67 B	148.13 A	1.32 A	38.5 B	35.0
MT03	1329.67 A	50.48 AB	33.15 A	150.83 BC	3.27 C	37.8 B	33.9
MT05	1307.9 AB	50.91 A	33.28 B	151.18 BC	2.27 B	39.7 A	34.5
CV	8.4	2.5	9.3	11.7	3.6	2.2	

- Locations planted within recommended planting dates.

Table 5. Yield Stability Analysis: High Yield to Low Yield Environments (Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad)*

	Regression value (b)	P value	Standard error +/-
Celine	0.604	P=0.16 ns	0.30
MT01	1.292	P=0.02 *	0.177
MT03	1.08	P=0.000 ***	0.095
MT05	1.017	P=0.01 **	0.135

Table 6. Chemical Characterization

	Iodine Number	Phytates	Sterols	Glucosinolates μmoles/g
Ligena	53.4	20.2	216.3	101.9
MT01	59.3	16.6	235.0	105.4
MT03	63.5	15.5	227.2	84.6
MT05	56.8	16.8	192.4	96.1

Recommendation

I recommend MT0301 be released by Montana State University and the Montana Agricultural Experiment Station in 2007. Seed increase will be done by the MAES research Centers in cooperation with the Montana Foundation Seed program.

I recommend the line MT0301 be named “Blaine Creek” as it is best adapted to high yield areas such as the Flathead Valley.

Montana 0303

MT0303 was observed to be higher yielding than the related plants within the germplasm plot and with excellent lodging resistance in the trial. MT0303 was increased as a plant-row in 2004 and entered into replicated trials in 2005 and 2006. MT0303 was selected from P.I. 597833 (Denmark) as a single plant selection from an increase block in 2003. MT0301 was observed to be significantly higher in yield than the related plants in the P.I. 597833 plot. MT0303 was increased as a plant-row in 2004 and entered into replicated trials in 2005 and 2006 at nine MAES stations. General data tables are attached as appendices. The cultivar, “Celine” is used as the control in all studies. Celine is a high omega 3 camelina variety developed in France.

MT0303 has several values of merit:

1. While all three lines exceed the yield of the control (Table 7, MT0303 has shown good average response across environments. This can be illustrated by its moderate yield stability analysis (b=1.08, Table 8) compared to Celine which was not as responsive to environment and performed better under stress environments (Knees, Denton).
2. Testweight for MT0301 were similar to the other MT lines.
3. Bloom date and maturity date for MT0301 were 2 to 5 days later for MT0303 than MT0301 and 4 days earlier than Celine, which is potentially useful in stressful environments. MT0303 also demonstrated the lowest level of lodging in high yield environments (Creston, Bigfork).
4. Shatter was disappointingly high in MT0301 and similar to Celine.
5. MO0303 was identified as lowest of the advanced lines in phytates and glucosinolates and compared favorably with Ligena, a commercial variety grown in Montana. MT0303 was superior to Celine in composite omega -3 (Ω-3) oil content and in ETA (the EPA precursor).
6. In general, MT0303 provided intermediate yield stability across environments and would be recommended for moderate to high yield environments, MT0303 is very good for lodging resistance and was intermediate in bloom and maturity to the other entrees in the trial.

Table 7. Yield trial characterization: Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad

	Yield lbs/acre	Test wt lbs/bu	Plant Ht inches	Bloom date (julian)	Shatter % at ripe	Oil % of seed	Ω- 3 oil %
Celine	1295.9 B	50.24 B	35.72 C	154.60 C	3.47 C	34.6 C	33.5
MT01	1348.3 A	51.12 A	33.67 B	148.13 A	1.32 A	38.5 B	35.0
MT03	1329.67 A	50.48 AB	33.15 A	150.83 B	3.27 C	37.8 B	33.9
MT05	1307.9 AB	50.91 A	33.28 B	151.18 BC	2.27 B	39.7 A	34.5
CV	8.4	2.5	9.3	11.7	3.6	2.2	

Table 8. Yield Stability Analysis: High Yield to Low Yield Environments (Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad)

	Regression value (b) P value	Standard error +/-
Celine	0.604 P=0.16 ns	0.30
MT01	1.292 P=0.02 *	0.177
MT03	1.08 P=0.000 ***	0.095
MT05	1.017 P=0.01 **	0.135

Table 9. Chemical Characterization

	Iodine Number	Phytates	Sterols	Glucosinolates µmoles/g
Ligena	53.4	20.2	216.3	101.9
MT01	59.3	16.6	235.0	105.4
MT03	63.5	15.5	227.2	84.6
MT05	56.8	16.8	192.4	96.1

Recommendation

I recommend MT0303 be released by Montana State University and the Montana Agricultural Experiment Station in 2007. Seed increase will be done by the MAES Research Centers in cooperation with the Montana Foundation Seed program.

I recommend the line MT0303 be named “Willow Creek” as it would be most suitable in the triangle region from Sunburst to Conrad and Havre.

Montana 0305

MT0305 was selected from P.I. 633192 (Germany) as a single plant selection from an increase block in 2003. MT0305 was observed to be similar in maturity to Celine without the problem of lodging. MT0305 was increased as a plant-row in 2004 and entered into replicated trials in 2005 and 2006. MT0305 was observed to be similar in maturity to MT0303 and higher in yield than the related plants in the P.I. 633192 plot. MT0305 was increased as a plant-row in 2004 and entered into replicated trials in 2005 and 2006 at nine MAES stations. General data tables are attached as appendices. The cultivar, “Celine” is used as the control in all studies. Celine is a high omega 3 camelina variety developed in France.

MT0305 has several values of merit:

1. While all three lines exceed the yield of the control (Table 7, MT0305 has shown a general yield response exceeding that of the control across mid-yield environments. Stability analysis shows MT0305 to be modestly responsive to its environment giving it an advantage in lower yielding locations. This can be illustrated by its high yield stability analysis (b=1.017, Table 8) and was comparable to Celine, which was not as responsive to environment and performed better under stress environments (Knees, Denton).
2. The greatest advantage to MT0305 is its oil percentage which significantly exceeds that of other camelinas in the trial across environments.

3. Bloom date and maturity date for MT0305 were similar to MT0303 which is potentially useful in stressful environments.
4. Shatter was significantly less in MT0305 than in the control or MT0303 and Celine.
5. MT0305 has excellent lodging resistance and moderate shatter resistance.
6. MT0305 was highest in α-linolenic acid (18:3 Ω- 3) of the lines and cultivar in trial.
6. Other quality characteristics (Table 12) were intermediate for chemistries other than phytosterols, where it was low.

Table 10. Yield trial characterization: Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad

	Yield lbs/acre	Test wt lbs/bu	Plant Ht inches	Bloom date (julian)	Shatter % at ripe	Oil % of seed	Ω- 3 oil %
Celine	1295.9 B	50.24 B	35.72 C	154.60 C	3.47 C	34.6 C	33.5
MT01	1348.3 A	51.12 A	33.67 B	148.13 A	1.32 A	38.5 B	35.0
MT03	1329.67 A	50.48 AB	33.15 A	150.83 BC	3.27 C	37.8 B	33.9
MT05	1307.9 AB	50.91 A	33.28 B	151.18 BC	2.27 B	39.7 A	34.5
CV	8.4	2.5	9.3	11.7	3.6	2.2	

Table 11. Yield Stability Analysis: High Yield to Low Yield Environments (Creston, Havre, Bigfork, Moccasin, Sunburst, Conrad)

	Regression value (b)	P value	Standard error +/-
Celine	0.604	P=0.16 ns	0.30
MT01	1.292	P=0.02 *	0.177
MT03	1.08	P=0.000 ***	0.095
MT05	1.017	P=0.01 **	0.135

Table 12. Chemical Characteristics.

	Iodine Number	Phytates	Sterols	Glucosinolates μmoles/g
Ligena	53.4	20.2	216.3	101.9
MT01	59.3	16.6	235.0	105.4
MT03	63.5	15.5	227.2	84.6
MT05	56.8	16.8	192.4	96.1

Recommendation

I recommend MT0305 be released by Montana State University and the Montana Agricultural Experiment Station in 2007. Seed increase will be done by the MAES research Centers in cooperation with the Montana Foundation Seed program.

I recommend the line MT0305 be named “Wolff Creek” as it is best adapted to areas such as the Central and North Central Montana.

Appendix Table 1. Yield trial data- all locations. Yields below 1,000 lbs/a are indicative of late planting.
Camelina Yield Trial Data

Location	Line	Yield lbs/acre					Ave Yld	
Year:		**2003**	**2004**	**2005**	**2006**			
Creston	Celine	2013	2025	1985		6023	2007.667	1039.155
(NWARC)	MT1		2175	2208		4383	2191.5	1316.15
	MT3		1987	1873		3860	1930	1237.457
	MT5		2014	1987		4001	2000.5	1214.265
Crossbow	Celine				1334.5	1334.5	1334.5	
(NWARC)	MT1				1155.2	1155.2	1155.2	
	MT3				1279.4	1279.4	1279.4	
	MT5				1070.5	1070.5	1070.5	
Crossbow	Celine				1803	1803	1803	
(NWARCII)	MT1					0	0	
	MT3					0	0	
	MT5				1486	1486	1486	
Denton	Celine				700	700	700	
Westbred	MT1					0	0	
	MT3					0	0	
	MT5				659	659	659	
Moccasin	Celine			993.5	1030	2023.5	1011.75	
(CARC)	MT1				1288	1288	1288	
	MT3				1084	1084	1084	
	MT5			867.7	1332	2199.7	1099.85	
Moccasin	Celine			669.1	1184	1853.1	1853.1	
(CARC II)	MT1			823.5	1131	1954.5	1954.5	
	MT3			877.8	1113	1990.8	1990.8	
	MT5			753.8	1250	2003.8	2003.8	
Huntley	Celine		597	1152		1749	874.5	
(SARC)	MT1					0	0	
	MT3					0	0	
	MT5					0	0	
Havre	Celine		792.3	1585		2377.3	1188.65	
(NARC)	MT1			1789		1789	1789	
	MT3					0	0	
	MT5			1590		1590	1590	
Cutbank	Celine			742		742	742	
(WTARC)	MT1			757		757	757	
	MT3			779		779	779	
	MT5			752		752	752	
Knees	Celine			463		463	463	
(WTARC)	MT1			395		395	395	
	MT3			411		411	411	
	MT5			438		438	438	
Sunburst	Celine		385			385	385	
(WTARC)	MT1					0	0	
	MT3					0	0	
	MT5					0	0	
Conrad	Celine		1013	1050		2063	1031.5	
(WTARC)	MT1			999		999	999	
	MT3			1188		1188	1188	
	MT5			1043		1043	1043	

Appendix Table 2. Test weight summary, all locations
CamelinaTest Weight Trial Data

Location	Line	lbs/bu					
Year:		**2003**	**2004**	**2005**	**2006**		
Creston	Gold of Pleasure	50.2	51	49.8		151	50.33333
(NWARC)	MT1		50.2	51		101.2	50.6
	MT3		51.2	52.3		103.5	51.75
	MT5		50.4	51.2		101.6	50.8
Crossbow	Celine				41.7	41.7	41.7
(NWARC)	MT1				41.2	41.2	41.2
	MT3				42.2	42.2	42.2
	MT5				42	42	42
Crossbow	Celine				53	53	53
(NWARCII)	MT1					0	0
	MT3					0	0
	MT5				54	54	54
Denton	Celine				52	52	52
Westbred	MT1					0	0
	MT3					0	0
	MT5				52	52	52
Moccasin	Celine			43.4	53.2	96.6	48.3
(CARC)	MT1				52.4	52.4	52.4
	MT3				53.88	53.88	53.88
	MT5			46.18	53.92	100.1	50.05
Moccasin	Celine			52.57	53.85	106.42	53.21
(CARC II)	MT1			51.17	53.8	104.97	52.485
	MT3			53.47	54.1	107.57	53.785
	MT5			52.95	54.3	107.25	53.625
Huntley	Celine		51.6	50.2		101.8	50.9
(SARC)	MT1					0	0
	MT3					0	0
	MT5					0	0
Havre	Celine		51.3	52.5		103.8	51.9
(NARC)	MT1			57.6		57.6	57.6
	MT3					0	0
	MT5			53.2		53.2	53.2

Appendix Table 3. Shatter rating.

Year:		2004	2005	2006		Ave Shatter	Ave Shatter/line
Creston	Celine	5	1		6	3	3.466666667
(NWARC)	MT1	0	0		0	0	1.316666667
	MT3	1	0		1	0.5	3.266666667
	MT5	1	0		1	0.5	2.266666667
Crossbow	Celine			1.3	1.3	1.3	
(NWARC)	MT1			1.3	1.3	1.3	
	MT3			3.8	3.8	3.8	
	MT5			1.3	1.3	1.3	
Havre	Celine	10	0	8.3	18.3	6.1	
(NARC)	MT1		0	5.3	5.3	2.65	
	MT3		0	11	11	5.5	
	MT5		0	10	10	5	

Appendix Table 4. Average Fatty acid Composition.

Line	Fatty acid%					
	Stearic	Oleic	Linoleic	Linolenic	ETA	DPA
	18:00	18:01	18:02	18:03	20:05	22:05
Celine	2.22	15.59	18.5	36.52	2.3	0.54
MT1	2.23	16.23	16.11	36.04	3	0.57
MT3	2.31	15.83	17.29	36.06	2.58	0.52
MT5	2.22	15.64	18.09	36.44	2.34	0.46
cv%	5.3	2.9	2.7	3.6	10.4	14.8

Appendix Table 5. Days to bloom.

Year:		2004	2005	2006		bloomdate	
Creston	Celine	158	155		313	156.5	154.6
(NWARC)	MT1	147	149		296	148	148.1333
	MT3	153	156		309	154.5	150.8333
	MT5	155	154		309	154.5	151.1833
Crossbow	Celine			156	156	156	
(NWARC)	MT1			153	153	153	
	MT3			154	154	154	
	MT5			155	155	155	
Havre	Celine		152.3	150.3	302.6	151.3	
(NARC)	MT1		142.2	144.6	286.8	143.4	
	MT3		144	144	288	144	
	MT5		142.8	145.3	288.1	144.05	

Appendix Table 6. Plant height.

Year:		2004	2005	2006		Height	Height/line
Creston	Celine	34	38		72	36	35.72222
(NWARC)	MT1	34	35		69	34.5	33.66667
	MT3	35	36		71	35.5	33.15
	MT5	35	36		71	35.5	33.28333
Crossbow	Celine			37.5	37.5	37.5	
(NWARC)	MT1			33.5	33.5	33.5	
	MT3			34	34	34	
	MT5			35	35	35	
Havre	Celine	34.6	35.2	31.2	101	33.66667	
(NARC)	MT1		38.6	27.4	66	33	
	MT3		32.3	27.6	59.9	29.95	
	MT5		31.8	26.9	58.7	29.35	