Canola – Biodiesel

Canola

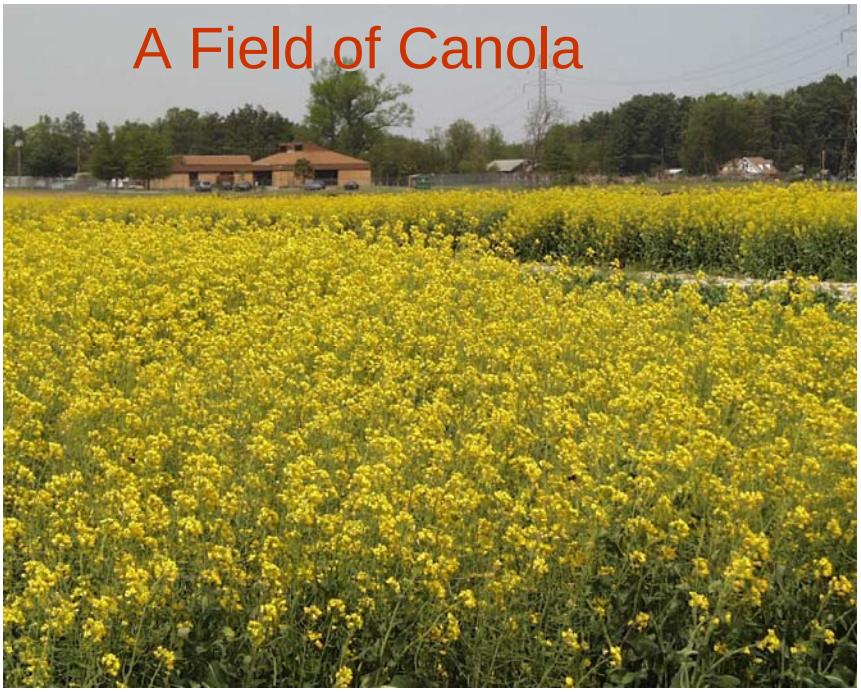
- **CANada Oil - Low Acid (Canola)**
  - **Canola Council of Canada**
- **Two species:**

  Brassica napus L.,
  ***Brassica rapa* L.**
- **Member of Mustard family - Brassicaceae. Brassica juncea, B. carinata, Sinapsis alba.**
- **Winter vs. Spring**

Canola/Rapeseed

- **Canola, essentially zero ERUCIC Acid (A 22:1 fatty acid) AND free of GLUCOSINOLATES (15 µ mol per gram). The oil and meal are edible.**
- **Rapeseed AKA INDUSTRIAL RAPESEED is high in ERUCIC ACID (up to approximately 30% of oil) and GLUCOSINOLATES (up to approximately 200 µ mol per gram). The oil and meal are NOT edible.**

A Field of Canola



Canola Seeds

Cooperation

- **Virginia State University (Bhardwaj) and Virginia Tech (Starner) have been evaluating canola for its potential as a winter crop since 1994 with funds from National Canola Research Program (USDA-CSREES).**
- **Orange, Petersburg, Suffolk.**

Canola in Virginia

Objectives

- **Develop a system of Production**
- **Identify/develop high yielding winter-hardy cultivars**
- **Develop alternative uses**
- **Disseminate the knowledge**

Production research - Planting time

Seed yield (t/ha), Suffolk

Oct. 1	**2.1 a**
Oct. 8	**2.0 a**
Oct. 15	**1.8 a**
Oct. 22	**1.2 c**

Production research - Planting time

Seed yield (t/ha), Petersburg

Sept. 29	**1.6 a**
Oct. 6	**1.6 a**
Oct. 13	**1.2 b**
Oct. 20	**0.4 c**

Production research - Planting time

Seed yield (t/ha), Orange

1993/94	**Oct. 4**	**.8 a**
	Oct. 15	**.2 b**
	Oct. 26	**.0 b**
1994/95	**Sept. 13**	**2.5 a**
	Sept. 28	**2.4 a**
	Oct. 7	**1.6 b**

Production Research

- **PLANTING TIME: Middle of September to early October in the Northern Piedmont, October in the Southern Piedmont, and up to middle of October in coastal plains.**

Production research - N fertilizer

Seed yield (t/ha), 1993/94

N Rate	Org	Pbg	Sfk	Mean
50	1.2 b	1.6 c	1.7 b	1.5 b
100	1.6 a	1.8 b	2.1 a	1.8 a
150	1.6 a	2.0 a	2.1 a	1.9 a
200	1.5 a	2.0 a	2.4 a	2.0 a

Production research - Sulfur 1998-99

Petersburg

S Rate (lb/acre)	Yield (lb/acre)	Oil%
0 lb/acre	1546 c	41.5 a
13 lb/ace	1574 c	32.3 a
26 lb/acre	1970 b	42.0 a
39 lb/acre	2412 a	40.6 a

Production research - Sulfur 2000-01 & 2001-02

Petersburg

S Rate (lb/acre)	Yield (lb/acre)	Oil%
0 lb/acre	2726 b	40.3 a
15 lb/ace	2679 b	40.3 a
30 lb/acre	3529 a	39.8 a
45 lb/acre	3810 a	39.8 a

* MS thesis research, Ron Bowen

Production research - Row Spacing, 1998-99

Petersburg

Row Spacing	Yield (lb/acre)	Oil (%)
6 inches	2584 a	38.5 a
12 inches	2151 a	39.4 a
18 inches	1733 a	40.0 a
24 inches	1944 a	41.1 a
30 inches	1750 a	39.4 a
36 inches	1962 a	40.1 a

Production research - Row Spacing, 2000-01 & 2001-02

Petersburg

Row Spacing	Yield (lb/acre)	Oil (%)
6 inches	3282 a	37.6 a
12 inches	3095 a	37.7 a
18 inches	2523 a	38.0 a
24 inches	3026 a	38.8 a
30 inches	2612 a	38.4 a
36 inches	2533 a	38.2 a

* Ms thesis research, Ron Bowen.

Production research - Seeding rate

Season	SD Rate	Seed Yield (lbs)
2002-03	4 pounds	3014 a
	8 pounds	3372 a
	12 pounds	3320 a
2001-02	4 pounds	1314 b
	8 pounds	2496 a
	12 pounds	2572 a

Production research - Variety Yields (lbs/acre)

Five Best Varieties at 3 Virginia Locations

2003-04: 3151 – 3397 (Mean = 3227)

2002-03: 2651 – 3060 (Mean = 2853)

2001-02: 2258 - 2660 (Mean = 2457)

2000-01: 1738 – 2206 (Mean = 1915)

Overall Mean: 2090 lbs/ace, 42 bushels

2007-08 Crop: 58 bu/acre (Rockingham)

Production research - N fertilizer

- **N approximately 100 pounds/acre should be adequate.**
- **No response to K fertilization but a positive yield response to P up to 100 pounds/acre.**
- **30 pounds/acre sulfur.**

Production Research

- **ROW SPACING: Most of the research has indicated that canola can be planted in rows varying from 6 to 36 inches. Recent data indicates that row spacing up to 18 inches might be the "BEST".**

Production Research

- **A yield level between 1915 and 3227 pounds/acre could be expected in Virginia.**
- **One farmer in Rockingham county grew VIRGINIA variety during 2007-08 crop season and harvested 58 bu/acre from about 50 acres.**

Quality of Canola Oil Produced in Virginia

- **The results indicated that oil from Virginia-grown canola was comparable to that grown in Canada in oil yield and fatty acids.**

Cultivar Development

- **Two high-yielding, locally-adapted cultivars have been developed.**
- **VSX-1 ("VIRGINIA") – marketed during 2006-07 and 2007-08 seasons.**
- **VSX-2 is being tested extensively.**
- **Others (Canola, Mustards).**

Winter rapeseed/canola varieties that would be suited to the climate and soil types of Eastern North Carolina

- **Mostly winter type of canola. Varieties identified to be high-yielding in Virginia should work well.**
- **Virginia, VSX-2**

How well can rapeseed/canola replace soybeans in a soy-wheat-corn rotation (e.g. are there timing or pest management issues)?

- **Canola could easily replace wheat in this rotation.**
- **If spring/summer rapeseed is adopted, it may work in place of soybean.**

Adaptation of existing harvesting equipment for harvesting rapeseed/canola

- **A small grain drill works great for planting in traditional row spacing of ~7-inches.**
- **A wheat combines works very well for harvesting, after some adjustments.**

Is it possible to modify existing soybean crushing facilities to crush rapeseed?

- **Yes (Based on my understanding of effort in Georgia, and other places).**
- **Alternatives exist.**

Estimated per acre average annual oil production for soy-canola-corn rotation vs soy-wheat-corn rotation

- **Average soybean yield is 32 bushels/acre (1600 pounds/acre). At ~ 20 % oil, 320 pounds of oil.**
- **Average canola yield is 40 bushels (2000 pounds/acre). At ~ 40% oil, 800 pounds of oil.**

Value and uses of canola meal as compared to soy meal

- **Canola meal is very nutritious.**
- **Biological Digestibility for pigs and poultry (Based on Amino Acids) is considered to be 10% LOWER than that for Soy Meal.**

"Crop budget" (production costs) for canola as compared to wheat

- **Canola is MORE profitable than winter wheat ???????????.**

BioDiesel

- **Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil.**
- **The process leaves behind two products -- methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products).**

Potential Biodiesel Feedstock Crops

- Any crop that produces oil is a candidate
- True oil crops: Canola/rapeseed, castor, cotton, mustard, peanut, sunflower, etc.
- Non-oil crops: Corn, Most Legumes, others.

Oilseed Crops and Oil Yields

Crop	gal/acre
Canola	127
Castor	151
Cotton	35
Lupine	25
Peanut	113
Soybean	48
Sunflower	102
Jatropha	202
Palm	635

OIL

Oil	Satu	UNS	Oil
Canola	7%	93%	40%
Sunflower	12%	88%	50%
Corn	13%	87%	3%
Soybean	15%	85%	20%
Peanut	19%	81%	60%
Cottonseed	27%	73%	20%
Castor	90%	10%	50%

Biodiesel

QUESTION

Which Crop?
Which Cultivar?

Answer: D6751

Biodiesel

D6751 (B-100)

Property		ASTM Method		Limits	Units
Calcium & Magnesium, combined		EN 14538		5 max	ppm (ug/g)
Flash Point (closed cup)		**D 93**		**93 min.**	**Degrees C**
Alcohol Control (One of the following must be met)					
1. Methanol Content		EN14110		0.2 Max	% volume
2. Flash Point		D93		130 Min	Degrees C
Water & Sediment	**D 2709**		**0.05 max.**	**% vol.**	
Kinematic Viscosity, 40 C		D 445		1.9 - 6.0	mm2/sec.
Sulfated Ash		D 874		0.02 max.	% mass
Sulfur					
S 15 Grade		**D5453**		**0.0015 m**	**% mass**
S 500 Grade		**D5453**		**0.05 max**	**% mass**
Copper Strip Corrosion		D 130		No. 3 max.	
Cetane	D 613		47 min.		
Cloud Point		**D 2500**		**Report**	**Degrees C**
Carbon Residue 100% sample	D 4530*		0.05 max.	% mass	
Acid Number		**D 664**		**0.50 max.**	**mg KOH/g**
Free Glycerin		**D 6584**		**0.020 m**	**% mass**
Total Glycerin		**D 6584**		**0.240 m**	**% mass**
Phosphorus Content	D 4951		0.001 m	% mass	
Distillation, T90 AET		D 1160		360 max.	Degrees C
Sodium/Potassium, combined		EN 14538		5 max	ppm
Oxidation Stability		**EN 14112**	**3 min**	**hours**	

Biodiesel

D6751 (B-100)

Flash point	93 minimum	Celsius
Alcohol Content		
Methanol	0.2 max	% volume
Flash Point	130 minimum	CELSIUS
Sulfur		
S15 grade	0.0015 max	% mass
S500 grade	0.05 max	% mass
Cetane	47 minimum	
Glycerin	0.240 max	% mass
Oxidative Stability	3 minimum	hours

Cetane numbers

- Octane numbers indicate the quality and value of gasoline.
- Cetane numbers indicate the quality and value of diesel fuel.
- It's a measure of a fuel's readiness to autoignite when it's compressed.
- The higher the cetane number, the more efficient the fuel.
- Biodiesel has a higher cetane number than petrodiesel because of its oxygen content.

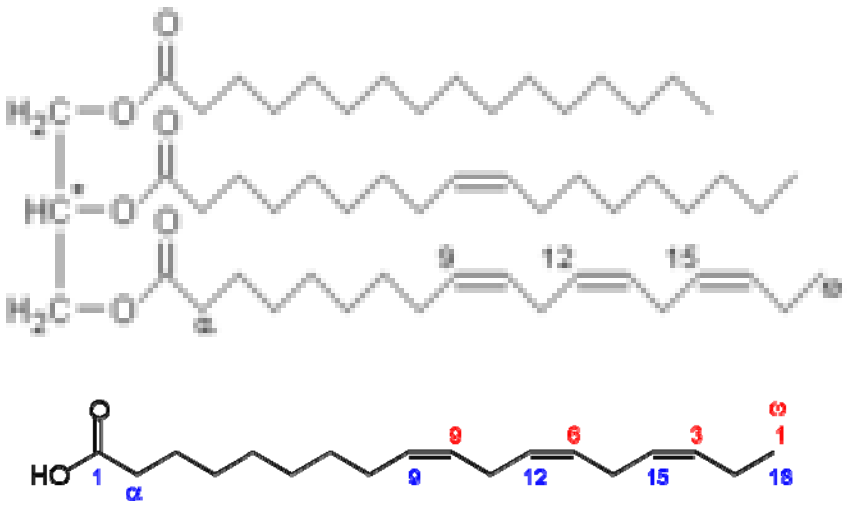
Cetane Numbers of Various Oils Before Processing into Biodiesel

Canola	37.6
Corn	37.6
Cotton	41.8
Peanut	41.8
Soybean	37.9
Sunflower	37.1

Making methyl esters in the processing into biodiesel will raise the cetane numbers.

Reported numbers for biodiesel range from 45 – 67.

OIL



OIL

- An oil consists of a glycerol back-bone and attached fatty acids.
- A fatty acid is made up of carbon atoms.
- Fatty acids from natural fats and oils have 8+ carbon atoms.

OIL

- **Low content of saturated fatty acids is linked to improved cold weather performance of BIODIESEL.**
- **Lower IODINE value oils result in more stable BIODIESEL.**
- **Oil content in the feedstock is important for oil yield.**
- **Low cloud point.**

Fatty Acids and Biodiesel quality

- C8:0, C10:0, C12:0, C14:0, C16:0, C18:0, C18:1, C18:2, C18:3, and C22:1 are important fatty acids.
- In plants (Canola, soybean), the important fatty acids for **BIODIESEL** are: C16:0, C18:0, C18:1, C18:2, and C18:3.
- C16:0 and C18:0 are important for cold flow quality.

Fatty Acids and Biodiesel quality

- Neal A. Bringe, Monsanto. Synthesized BIODIESEL with optimal composition.
- Optimal for Cold flow, Cetane number, improved oxidative stability, reduced N-oxide.
- C18:1 = 71.3% C18:2 = 21.4 %
- C18:3 = 2.2 %C16:0 = 2.1 %
- C18:0 = 1.0 %Others = 2.0 %

Fatty Acids and Biodiesel quality

- The synthesized BIODIESEL was comparable, in general, to petroleum biodiesel.
- Considerations related to food use of many oils vs. their use as biodiesel feedstock ARE important. Higher PUFA leads to oxidation but are essential in human diet.

Typical Fatty Acids

	Canola	Flax	Vernonia	Soy
C16:0	4.9*	7.0**	3.3**	2.1***
C18:0	1.4	6.0	3.0	0.7
C18:1	63.5	24.0	5.0	4.3
C18:2	19.5	20.0	14.9	9.9
C18:3	8.1	45.0	0.1	1.3

- Hamama and Bhardwaj 2003 JAOCS
- ** Bhardwaj, unpublished data
- *** USDA

Biodiesel vs. Fatty Acids in Oil

- Selection Index
- Better oil will be as close as possible to target composition.
- C18:1 = 71.3% C18:2 = 21.4 %
- C18:3 = 2.2 % C16:0 = 2.1 %
- C18:0 = 1.0 % Others = 2.0 %

Biodiesel vs. Fatty Acids in Oil

- C18:1 = 71.3% C18:2 = 21.4 %
- C18:3 = 2.2 % C16:0 = 2.1 %
- C18:0 = 1.0 % Others = 2.0 %
- Larger the difference between the fatty acids in the oil and those in the target, the least desirable will be oil as feedstock.
- Smaller the difference between the fatty acids in the oil and those in the target, the more desirable will be oil as feedstock.

Example

- 455 accessions of *Brassica napus* L.
- 44 accessions of *Brassica rapus* L.
- Fatty acid data
- Selection Index

  napus : 31.7 to 81.2 mean= 66.0

  rapus : 63.6 to 81.3 mean= 73.9
- *Brassica napus* is a better feedstock.

Example

FA	Canola	Flax	Vernonia	Soy
C16:0	4.9	7.0	3.3	2.1
C18:0	1.4	6.0	3.0	0.7
C18:1	63.5	24.0	5.0	4.3
C18:2	19.5	20.0	14.9	9.9
C18:3	8.1	45.0	0.1	1.3
Sel. Index	**20.6**	**102.2**	**79.9**	**100.5**

Fatty Acids & Biodiesel

- **Preliminary correlation analysis indicates that the selection index, collected from fatty acid composition of oils, is practical for use when comparing crops and/or cultivars.**
- **Further studies are in progress.**

Biodiesel

- Vegetable Oil (oilseed crops)
- Used vegetable oil
- Quality of biodiesel depends upon the quality of oil.
- ***** IMPROVED OXIDATIVE STABILITY and IMPROVED COLD FLOW PROPERTIES *****

Canola/Rapeseed Oil for BioDiesel

- **Might be desirable than soybean oil because of high yield.**
- **Normally ONE gallon of vegetable oil produces ONE gallon of BioDiesel.**
- **For every BTU used to produce the crop and process the oil, 3.3 BTU's are produced as fuel.**

Canola/Rapeseed Oil for BioDiesel

- **Rapeseed oil may be more desirable than canola oil due to higher content of ERUCIC acid.**
- **Higher the content of long-chain fatty acids, higher the return from conversion of vegetable oils for BioDiesel.**

Canola/Rapeseed Oil for BioDiesel

- **Federal requirements regarding low sulfur content of diesel will result in lower viscosity of Diesel fuel.**
- **Biodiesel i.e. Diesel plus BioDiesel could solve these problems.**

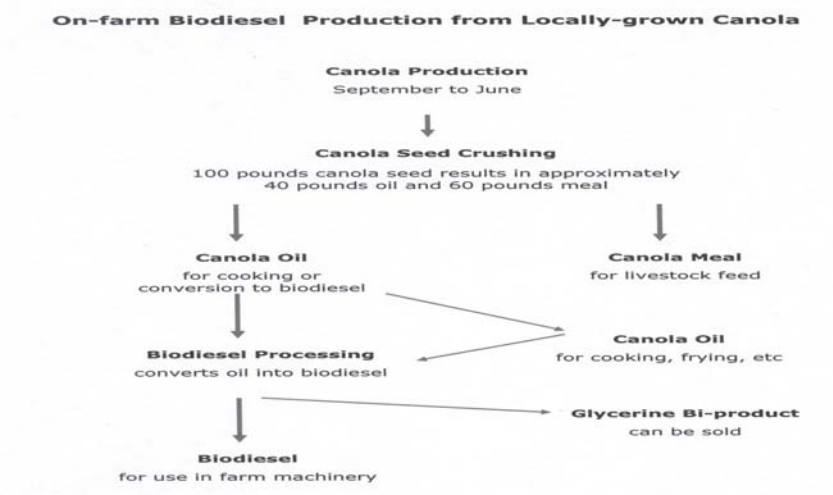
Canola/Rapeseed Oil for BioDiesel

- **Blue Sun Biodiesel from Colorado is using mustard oil.**
- **Virginia State has some breeding material under study that has potential.**
- **This material, when planted in March, could be harvested in early July (120 days).**

Canola/Rapeseed Oil for BioDiesel

- **The oil content of this MUSTARD material is approximately 30 %. The average seed yield (Preliminary observations) is around 1800 pounds/acre.**

Canola - BioDiesel
Fuel vs. Food



Canola Field Day

- **June 19, 2008**
- **Lanexa, New Kent County**
- **Demonstrations:**
  - **Canola harvesting**
  - **Canola crushing to get oil**
  - **Conversion of oil into BIODIESEL**
  - **Biodiesel utilization in farm machinery.**

Canola Field Day




2008-09 Plan

- **One farmer + one extension person**
- **From each of the 6 extension districts in Virginia**
- **Free seed, financial support to the farmer and the extension person**
- **Field days in June/July, 2009**

Canola in Virginia
Bottom line

Jatropha

- *Jatropha curcus*
- Perennial, Drought-tolerant
- 37% oil content
- Small tree
- 5000-7000 lb/acre
- TROPICAL
- Origin Mexico and Central America, likes HOT climate

Canola – Biodiesel

Virginia State University
Petersburg, VA
Harbans L. Bhardwaj