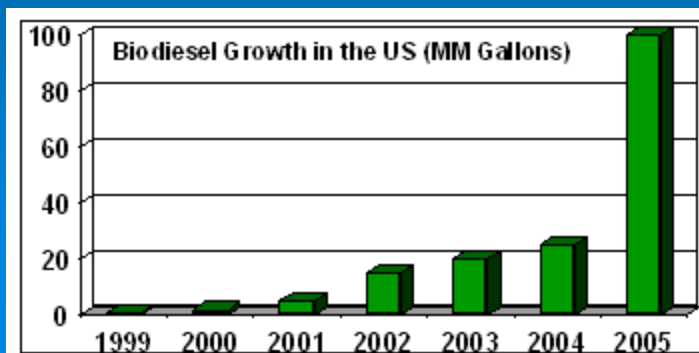
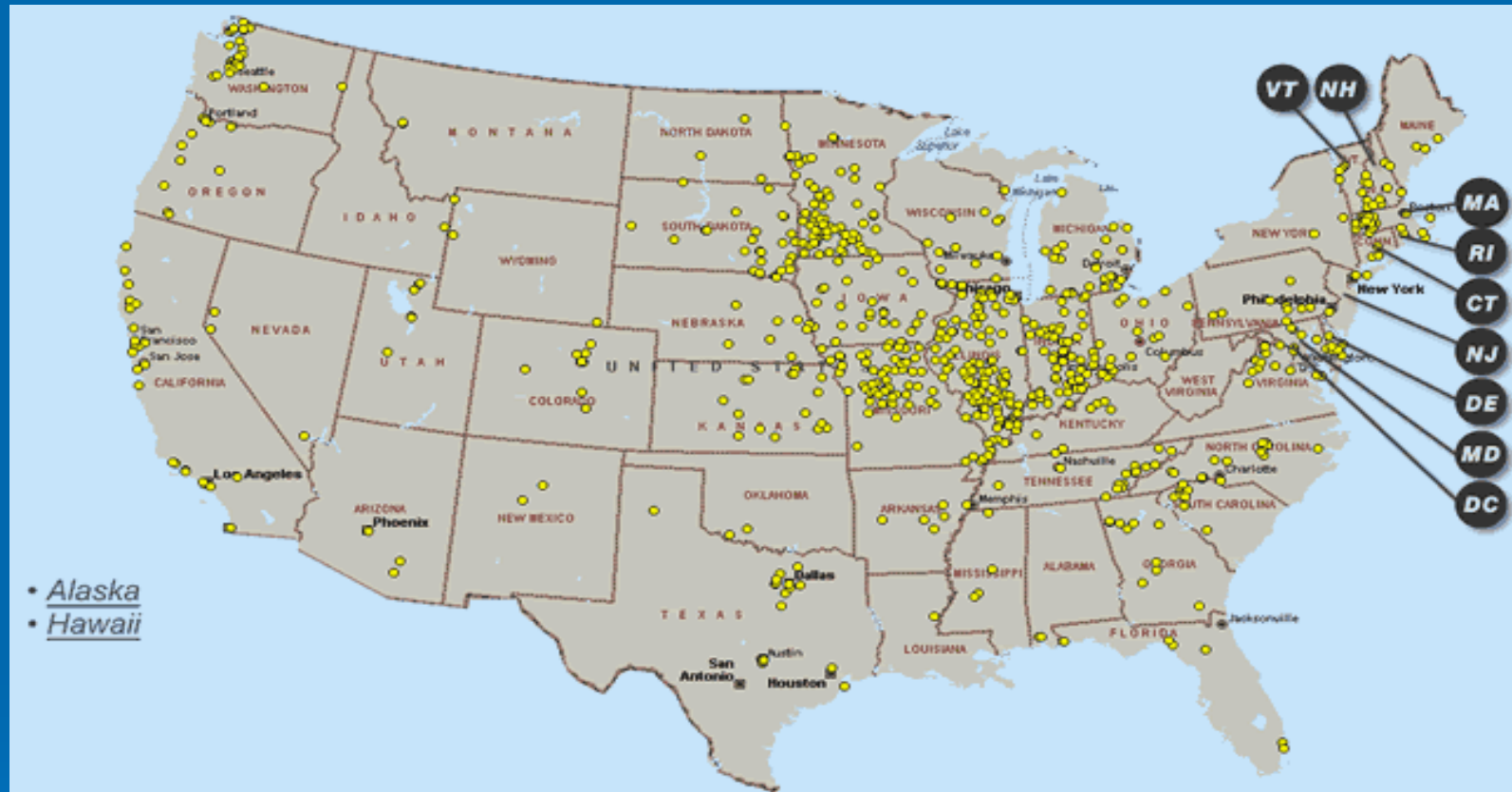


# Evaluation of Genetic Diversity of Castor Bean for Biodiesel Utilization

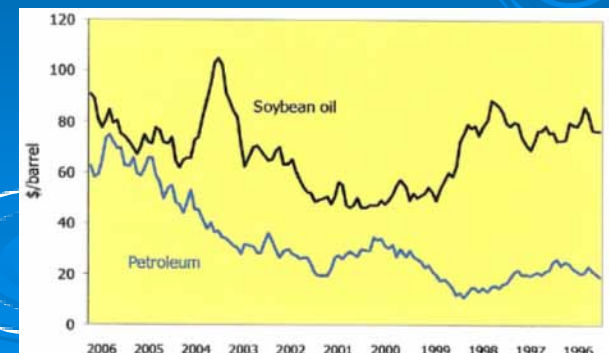
Ming Li Wang, Brad Morris, Gary Pederson

USDA-ARS-PGRCU, Griffin, Georgia

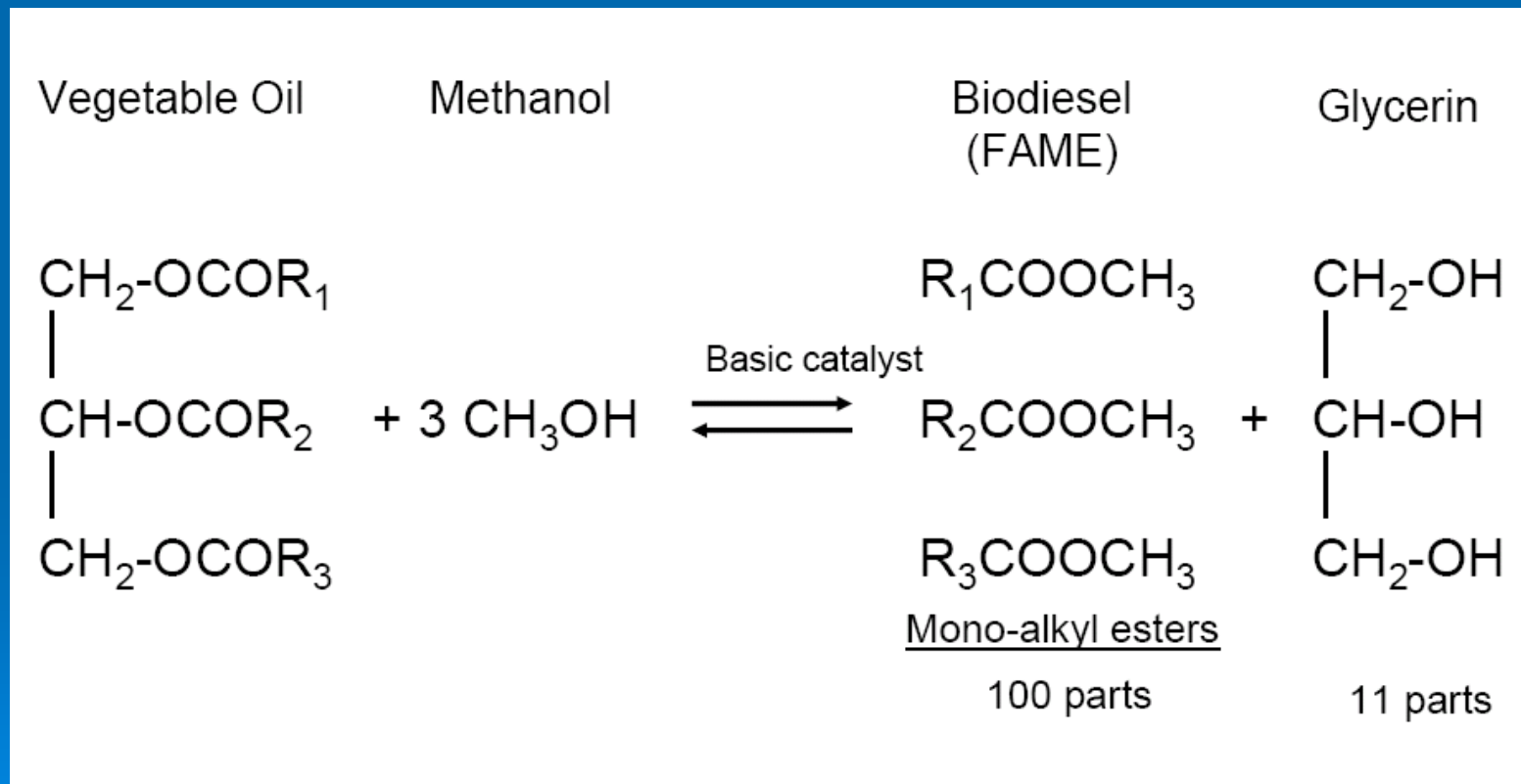
# Biodiesel Production and Consumption in USA



90% biodiesel  
produced in USA  
from soybean oil



# Convert Fatty Acids to Fatty Acid Methyl Esters (FAME)



# Advantages by Using Biodiesel

## Ø Environmentally Friendly

Low CO<sub>2</sub> and SO<sub>2</sub> emission (98% less)

Low benzene and particulates

Fast biodegradability

## Ø Energy Renewable

Fats from animals

Oils from oilseed crops

## Ø Positive Impact on Agriculture

Renewable biomass



# Oil Content of Oilseed Crops

|                                 |            |
|---------------------------------|------------|
| Ø Soybean seeds                 | 18-20% oil |
| Ø Sunflower seeds               | 10-50% oil |
| Ø Canola seeds                  | 40-46% oil |
| Ø Cotton seeds                  | 20-33% oil |
| Ø Flax seeds                    | 40-60% oil |
| Ø Peanut seeds                  | 45-55% oil |
| Ø Castor bean seeds             | 35-50% oil |
| Ø Others (mustard and camelina) |            |

# Why Castor Bean Oil for Biodiesel

- Ø Castor bean plants are easy to grow
- Ø Resistant to drought (ideal crop for semi-arid area or desert)
- Ø Not compete with lands for agricultural production
- Ø High oil content in castor bean seeds
- Ø Relatively high viscosity and specific gravity
- Ø Castor bean oil is soluble in ethanol
- Ø Not require heat for converting oil into fuel
- Ø Brazil has used castor oil for biodiesel production

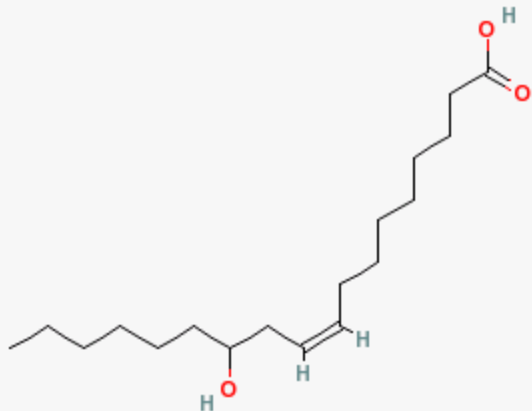


# General Features of Castor Bean

- Ø *Ricinus communis*  $2n = 20$
- Ø Belong to family Euphorbiaceae not Leguminosae
- Ø Cross-pollinated diploid species
- Ø Originate from Africa or India
- Ø Use as annual or perennial crops
- Ø Ricin A inactivates ribosomes  
Inhibit protein synthesis
- Ø Germplasm maintained in USDA-ARS,  
PGRCU, Griffin, Georgia, 1043 accessions

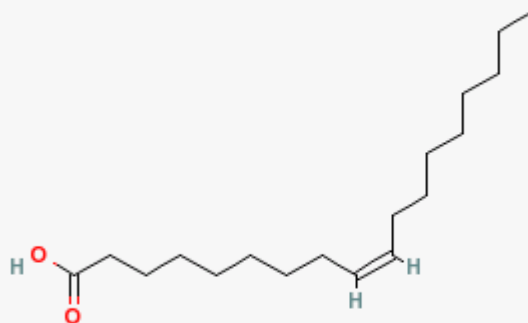
# Castor Oil Composition (Eight major fatty acids)

89.5%



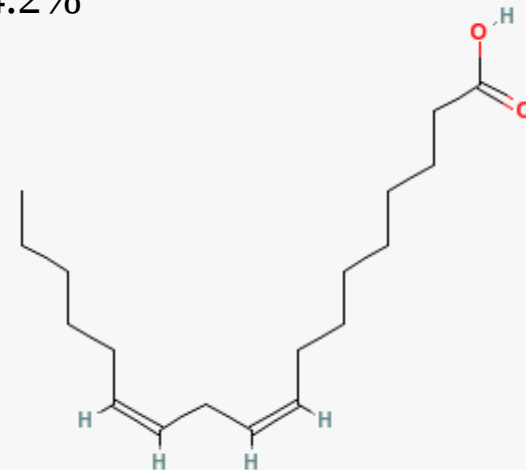
Ricinoleic acid, MF  $C_{18}H_{34}O_3$ , MW 298.461

3.0%



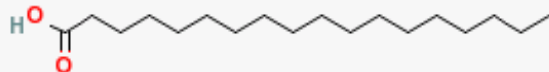
Oleic acid, MF  $C_{18}H_{34}O_2$ , MW 282.461

4.2%



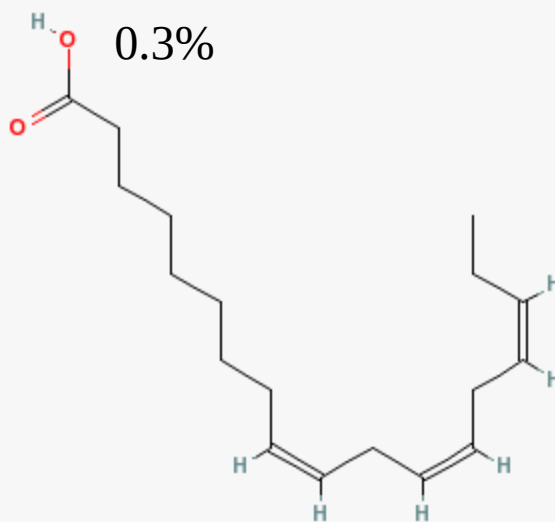
Linoleic acid, MF  $C_{18}H_{32}O_2$ , MW 280.445

1.0%



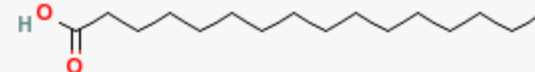
Stearic acid, MF  $C_{18}H_{36}O_2$ , MW 284.477

0.3%



Linolenic acid, MF  $C_{18}H_{30}O_2$ , MW 278.43

1.0%



Palmitic acid, MF  $C_{16}H_{32}O_2$ , MW 256.424



# Selected castor bean accessions

| Accession | Species                    | Collection site | Accession | Species                    | Collection site       |
|-----------|----------------------------|-----------------|-----------|----------------------------|-----------------------|
| PI 170684 | <i>Ricinus communis</i> L. | Turkey          | PI 240674 | <i>Ricinus communis</i> L. | Uruguay               |
| PI 173946 | <i>Ricinus communis</i> L. | India           | PI 244573 | <i>Ricinus communis</i> L. | Brazil                |
| PI 181916 | <i>Ricinus communis</i> L. | Syria           | PI 246996 | <i>Ricinus communis</i> L. | Bahamas               |
| PI 184133 | <i>Ricinus communis</i> L. | Yugoslavia      | PI 247097 | <i>Ricinus communis</i> L. | Iran                  |
| PI 193851 | <i>Ricinus communis</i> L. | Ethiopia        | PI 248424 | <i>Ricinus communis</i> L. | Zaire                 |
| PI 195811 | <i>Ricinus communis</i> L. | Guatemala       | PI 250574 | <i>Ricinus communis</i> L. | Egypt                 |
| PI 197048 | <i>Ricinus communis</i> L. | Salvador        | PI 250939 | <i>Ricinus communis</i> L. | Iran                  |
| PI 201781 | <i>Ricinus communis</i> L. | Brazil          | PI 253620 | <i>Ricinus communis</i> L. | Morocco               |
| PI 201830 | <i>Ricinus communis</i> L. | Madagascar      | PI 255238 | <i>Ricinus communis</i> L. | Mexico                |
| PI 203661 | <i>Ricinus communis</i> L. | Paraguay        | PI 257653 | <i>Ricinus communis</i> L. | Former Soviet Union   |
| PI 204322 | <i>Ricinus communis</i> L. | India           | PI 258388 | <i>Ricinus communis</i> L. | Algeria               |
| PI 206515 | <i>Ricinus communis</i> L. | Jamaica         | PI 262553 | <i>Ricinus communis</i> L. | Bulgaria              |
| PI 208464 | <i>Ricinus communis</i> L. | Nepal           | PI 265504 | <i>Ricinus communis</i> L. | US                    |
| PI 209132 | <i>Ricinus communis</i> L. | Puerto Rico     | PI 271861 | <i>Ricinus communis</i> L. | Ecuador               |
| PI 209326 | <i>Ricinus communis</i> L. | Virgin Islands  | PI 274771 | <i>Ricinus communis</i> L. | South Africa          |
| PI 209436 | <i>Ricinus communis</i> L. | Panama          | PI 277024 | <i>Ricinus communis</i> L. | Argentina             |
| PI 209623 | <i>Ricinus communis</i> L. | Cuba            | PI 280219 | <i>Ricinus communis</i> L. | Greece                |
| PI 212115 | <i>Ricinus communis</i> L. | Afghanistan     | PI 306724 | <i>Ricinus communis</i> L. | China                 |
| PI 215768 | <i>Ricinus communis</i> L. | Peru            | PI 323589 | <i>Ricinus communis</i> L. | Portugal              |
| PI 215769 | <i>Ricinus communis</i> L. | Peru            | PI 426929 | <i>Ricinus communis</i> L. | Pakistan              |
| PI 219766 | <i>Ricinus communis</i> L. | Botswana        | PI 436592 | <i>Ricinus communis</i> L. | China                 |
| PI 221698 | <i>Ricinus communis</i> L. | Indonesia       | PI 631156 | <i>Ricinus communis</i> L. | US                    |
| PI 240310 | <i>Ricinus communis</i> L. | Benin           | PI 638788 | <i>Ricinus communis</i> L. | Israel                |
| PI 240311 | <i>Ricinus communis</i> L. | Cambodia        | PI 642000 | <i>Ricinus communis</i> L. | US (Hale, a cultivar) |

# Plant Castor Bean Accessions

## REPLICATE 1

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  |
| 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |

## REPLICATE 2

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 11 | 47 | 33 | 2  | 22 | 29 | 39 | 14 |
| 34 | 32 | 8  | 42 | 45 | 24 | 9  | 5  |
| 12 | 26 | 46 | 36 | 27 | 16 | 21 | 1  |
| 35 | 31 | 20 | 17 | 6  | 13 | 44 | 48 |
| 18 | 28 | 43 | 4  | 3  | 37 | 40 | 15 |
| 19 | 30 | 23 | 41 | 25 | 38 | 10 | 7  |

# Castor Bean Field Plots





# Castor Bean Field Plots



# Castor Bean Flowers and Bagging





# Hydraulic Plant Press for Oil Extraction







# From Castor Bean Seeds to Castor Oil



| Accession | Oil content (%) | Tukey grouping | Accession | Oil content (%) | Tukey grouping | Accession | Oil content (%) | Tukey grouping |
|-----------|-----------------|----------------|-----------|-----------------|----------------|-----------|-----------------|----------------|
| PI 240674 | 37.15           | a              | PI 436592 | 31.97           | bcdefghijkl    | PI 209326 | 29.23           | klmnopqr       |
| PI 274771 | 35.04           | ab             | PI 208464 | 31.85           | bcdefghijklm   | PI 197048 | 29.17           | klmnopqr       |
| PI 195811 | 35.03           | abc            | PI 271861 | 31.82           | defghijklm     | PI 280219 | 29.05           | lmnopqr        |
| PI 306724 | 34.88           | abcd           | PI 206515 | 31.80           | defghijklm     | PI 184133 | 28.83           | lkmnopqr       |
| PI 265504 | 34.72           | abcde          | PI 204322 | 31.57           | efghijklmn     | PI 638788 | 28.68           | mnopqrs        |
| PI 209132 | 34.60           | abcde          | PI 209623 | 31.33           | fghijklmno     | PI 173946 | 28.52           | nopqrs         |
| PI 221698 | 34.57           | abcde          | PI 253620 | 30.93           | fghijklmnop    | PI 212115 | 28.47           | nopqrs         |
| PI 215769 | 34.13           | abcdef         | PI 257653 | 30.75           | ghijklmnop     | PI 277024 | 28.29           | opqrs          |
| PI 323589 | 33.94           | bcdefg         | PI 250574 | 30.59           | hijklmnop      | PI 201781 | 28.16           | opqrs          |
| PI 248424 | 33.89           | bcdefg         | PI 170684 | 30.50           | hijklmnopq     | PI 247097 | 27.99           | pqrs           |
| PI 262553 | 33.88           | bcdefg         | PI 244573 | 30.25           | ijklmnopq      | PI 209436 | 27.37           | qrs            |
| PI 246996 | 33.56           | bcdefgh        | PI 240310 | 29.81           | jklmnopqr      | PI 215768 | 26.95           | rs             |
| PI 193851 | 33.26           | bcdefghi       | PI 181916 | 29.78           | jklmnopqr      | PI 258388 | 25.51           | s              |
| PI 203661 | 32.71           | bcdefghij      | PI 201830 | 29.73           | jklmnopqr      | PI 219766 | 21.26           | s              |
| PI 240311 | 32.59           | bcdefghij      | PI 250939 | 29.55           | jklmnopqr      | Average   | 30.98           |                |
| PI 255238 | 32.33           | bcdefghijk     | PI 642000 | 29.25           | klmnopqr       |           |                 |                |

# Germination of Fallen Castor Bean Seeds





# Shattering with Empty Seed Capsules





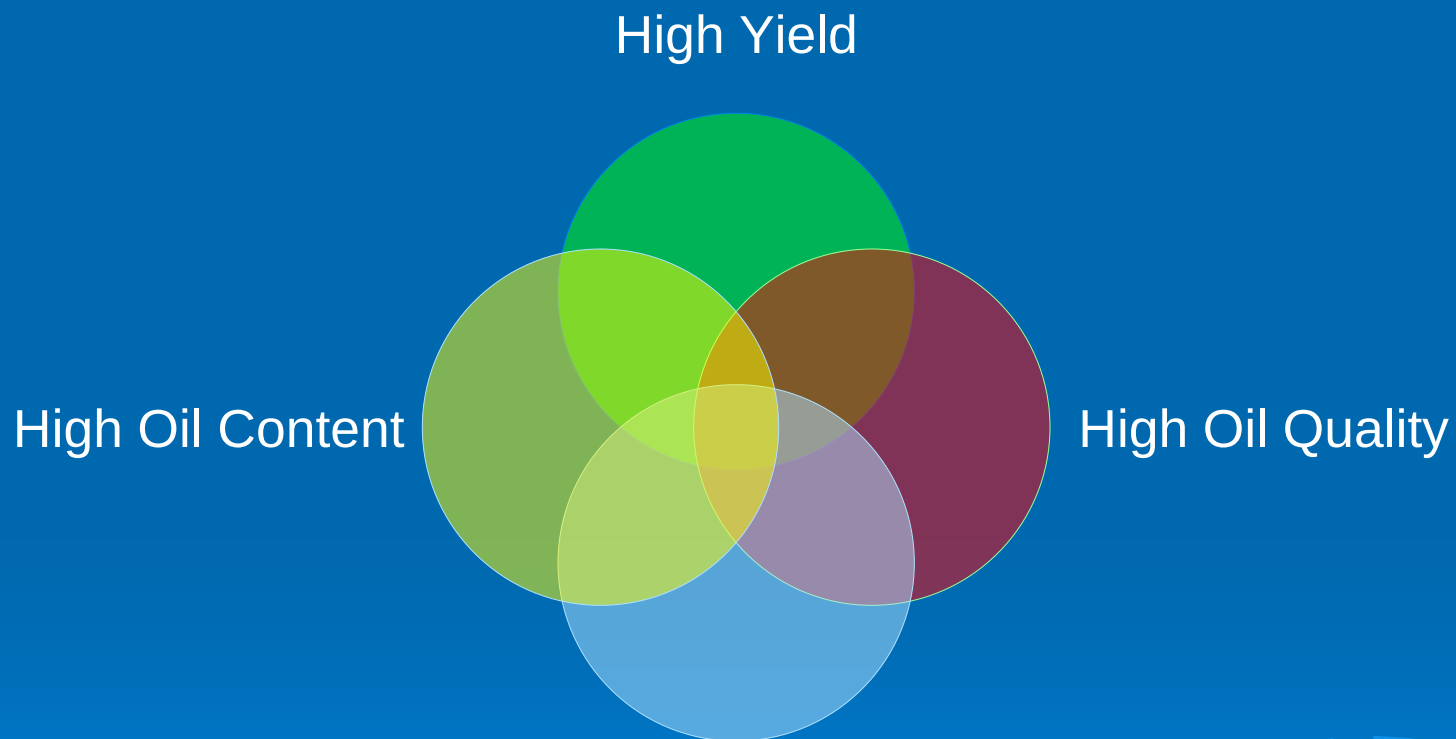
# None-Shattering with Seed Capsules



# Challenges Faced for Using Castor Bean as Feedstock for Biodiesel Production

- Ø Avoid out-crossing among accessions
  - Ø Avoid seed shattering
  - Ø Lodging affect yield and harvest
  - Ø Plants too high pose problem for harvest
  - Ø Ricin poisoning affect using byproduct
  - Ø Increase converting rate from oil to biodiesel
- 
- The bottom right corner of the slide features a decorative graphic of several concentric, light blue circles, resembling ripples on water, set against the solid blue background.

# Future Research Direction



Genetic Diversity

# Acknowledgements

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