# Adaptation of Camelina as a Northwest Oilseed Crop

***Camelina sativa***

- A small-seeded oilseed crop in the Mustard family.
- Relatively new, commercially, in North America.
- Performs well in the inland Pacific Northwest.
- Has great potential as a wheat rotations crop in PNW low/intermediate rainfall regions (roughly 6 M acres).
- Water requirements are relatively low.
- Oil has good properties for biodiesel and advanced biofuels.
- Meal is high in protein and low in glucosinolates (with varietal differences).
- Residual oil in meal is high in Omega 3 fatty acids.
- Is currently a non-food crop, which is attractive to some potential oil-buyers and from a genetic engineering standpoint.
- Is closely related to Arabidopsis and easily transformed.

Wheat-fallow rotations in the PNW are not sustainable due to soil erosion

# Camelina has potential for intensifying cropping systems

- Can yield well in low/intermediate rainfall region (e.g. La Crosse trial) planted after wheat instead of fallow
- Wheat/Camelina or wheat/Camelina/fallow rotation could replace wheat/fallow rotation in large acreages, intensifying the cropping system

Camelina trial in low rainfall region

La Crosse 2008 trial

| Variety | lbs/acre |
|---|---|
| Calena | 2016 |
| Suneson | 1621 |
| Blain Creek | 1695 |
| Ligena | 1741 |
| Columbia | 1550 |
| Celine | 1764 |
| Cheyenne | 1766 |

# Theoretical potential oil in *Dryland* Northwest from camelina

| Region: | acres*: | Yld Pot. | Years in Camelina | Ann. prod (M lbs) |
|---|---|---|---|---|
| Inland PNW **low rainfall** | 3.8M | 700 lbs | 1 in 3 = 1.27M | 887 |
| Inland PNW **intermediate** | 2.4M | 1500 lbs | 1 in 3 = 0.8M | 1200 |
| Inland PNW **high** | 2.0M | 2200 lbs | 1 in 3 = 0.67M | 1474 |
| Intermountain region | 2.0M | 1500 lbs | 1 in 3 = 0.67M | 1000 |
| Montana | 7.0M | 700 lbs | 1 in 3 = 2.3M | 1610 |
| Total | | | | 6171 |

6090 M lbs x 33% oil = 1650 M lbs oil X 7.6 lbs / gal = 264 million gallons*

* Gallons of Jet fuel depends on conversion rates

# Barriers to large scale Camelina production

- Competitive price required for grower adoption: Price depends on good markets for both oil and co-products (meal)
- Markets for co-products (meal >60% of seed weight) are still under development: In recent developments FDA claimed no objection to 10% feed ration for broilers, laying hens, feed-lot cattle.
- Only a few companies are contracting for production.
- Few companies have experience making biodiesel from it.
- Few PNW farmers have experience in growing it.
- Few breeding programs or seed dealers.
- Best varieties for different regions are unknown.

- Agronomics are not well characterized: e.g. nutrient and water requirements, disease problems, best planting methods.
- Only one herbicide (Poast) currently registered.
- Camelina is highly sensitive to group 2 herbicides, which are widely used in the PNW and have long soil residual activity.

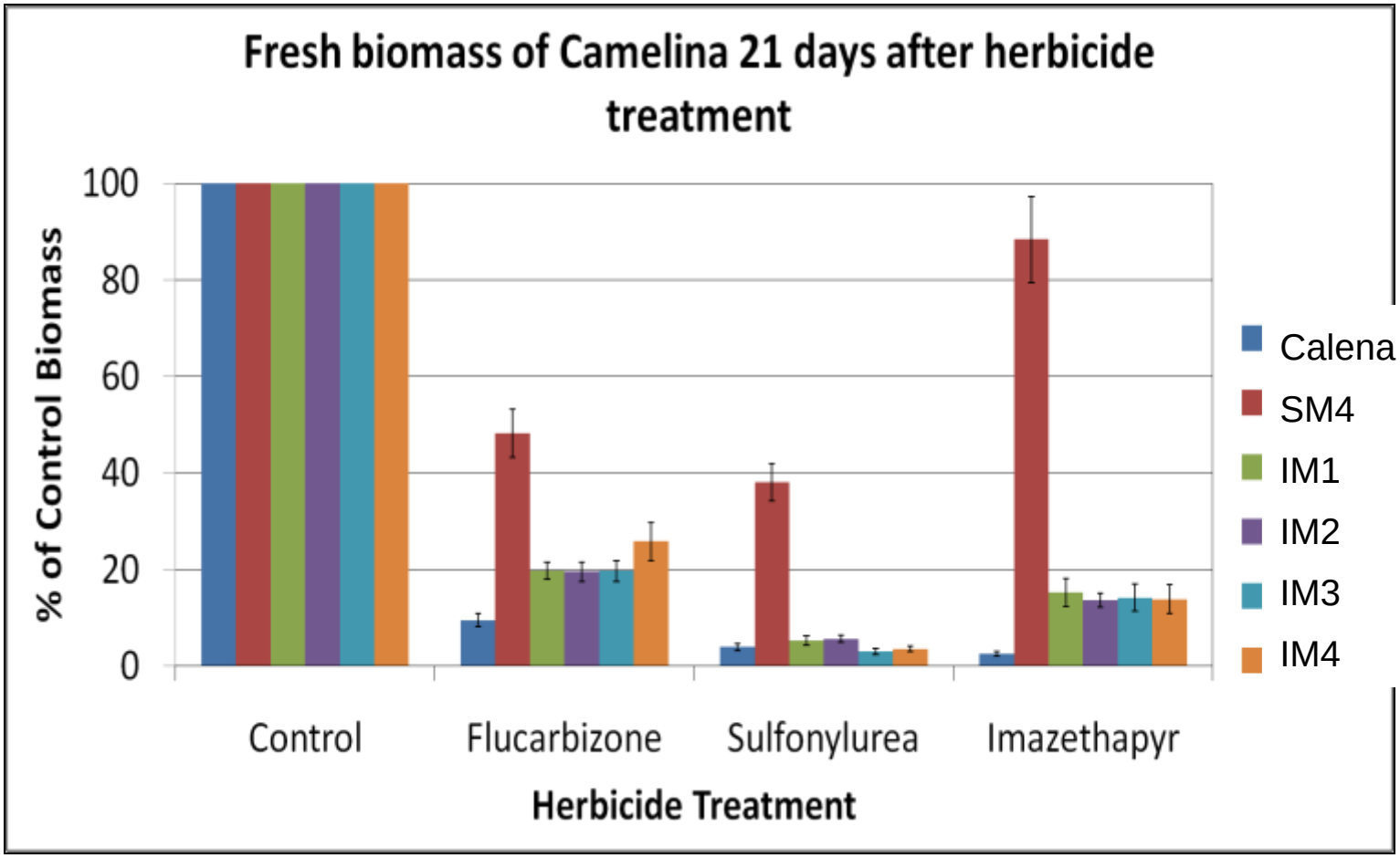
Mutant camelina lines selected for group 2 herbicide resistance

IM1,1 oz pursuit  Unsprayed Control  Control 1 oz pursuit

# Target Herbicides

| Herbicide | Trade Name | Rate |
|---|---|---|
| Imazethapyr | Pursuit | 3 oz/acre |
| Imazamox | Beyond | 4 oz/acre |
| Sulfosulfuron | Maverick | 0.33 oz/acre |
| Flucarbizone | Everest | 0.6 oz/acre |

# Resistance spectrum of the mutants



# SM4 and IM1, 21 days after treatment.


# Nucleotide substitution *probably* causing the resistance in SM4

**DNA sequence**

```
Cheyenne   TTGGCATGGTTATGCAATGGGAGGATCGGTTCTACAAAGCTAACCGA
SM4        TTGGCATGGTTATGCAATGGGAGGATCGGCTCTACAAAGCTAACCGA
```

**Amino acid sequence** **578**

```
Cheyenne   LATIRVENLPVKILILNNQHLGMVMQWEDRFYKANRAHTYLGNPAAE
SM4        LATIRVENLPVKILILNNQHLGMVMQWEDRLYKANRAHTYLGNPAAE
```

# Multiple ALS genes in the SM4 line

```
SM4-1-GEN      TTGTAAGGTCCTGATTGCTCCTTGTCTCTCGAGACGTTAACTCAATAG
SM4-2-GEN      TTGTAAGGTCCTGATTGCTCCTTGTTTCTCGAGACGTTAACTCCGTAT
SM4-4-GENO     TTGTAATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-1B-GEN     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-2-CDNA     TAACTGGCTTTTAGCGGACCACCGTCCCGTAAGTCATCGACTTGGTAT
SM4-4-CDNA     TAACTGGCTTTTAGCGGACCACCGTCCCGTAAGTCATCGACTTGGTAT
SM4-1-CDNA     CAGTTGGCTTTTAGTGGACCACCGTCCCGTAAGTCATTAACTTAATGT
SM4-5-CDNA     CAGTTGGCTTTTAGTGGACCACCGTCCCGTAAGTCATTAACTCAACAT
SM4-5-CDNA     CAGTTGGCTTTTAGCGGACCACCGTCCCGTAAGTCATTAACTCAATAT
SM4-7-CDNA     CAGTTGGCTTTTAGTGGACCACCGTCCCGTAAGTCATTAACTCAATAT
SM4-2-CDNA     CAGTTGGCTTTTAGTGGACCACCGTCCCGTAAGTCATTAACTCAATAT
SM4-3-CDNA     CAGTTGGCTTTTAGTGGACCACCGTTCTTTATTTTGTGATTACCGTGT
SM4-6-CDNA     TTGTAAGGTCCTGATTGCTCCTTGTTCTTTATTTTGCGATTACCGTAT
SM4-1-CDNA     TTGTAAGGTCCTGATTGCTCCTTGTTCTTTATTTTGCGATTACCGTAT
SM4-3-CDNA     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-4-CDNA     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-6-CDNA     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-7-CDNA     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
SM4-8-CDNA     TAATTATGCTTGAATTTCTTCCTTCCTCTCGAGACGTTAACTCAATAG
```

Only informative polymorphic bases shown

# Summary:

- There are still many economic , regulatory, and knowledge deficiencies before camelina becomes a major crop in the PNW

- Incorporating the SM4 gene into good cultivars may prevent the residual activity problem with group 2 herbicides, make it less risky for growers to try camelina and help them fit it into their crop rotations.

- More field experiments are needed to make recommendations for its use, but seed is available for breeders to start incorporating it.

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## Funding support:

WSDA biofuels program
SunGrant Initiative

USDA Agricultural Research Service
www.ars.usda.gov