Title: Development of Camelina Varieties Resistant to Group 2 Herbicides

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Technical Support: Josh DeMacon

Background:
Camelina has potential as an oilseed crop and valuable rotation crop in the dryland farming areas of Eastern Washington but is extremely sensitive to ALS-inhibitor (group 2) herbicides. Earlier work identified a mutation that conferred tolerance to these herbicides and have now breed this mutation into a high yielding, high oil content variety. The first breeding population (population A) was derived from a cross between our favorite herbicide tolerant (HT) mutant SM4, in the variety Cheyenne background, and the variety Calena. Several series of field selections were conducted among 500 lines established from this cross. In 2013 the best 50 lines were evaluated in multiple locations and nine lines which performed better than our favorite check cultivar Calena, were selected for testing in 2014.

Methods and Results:

Objective 1: Select the best performing line from breeding population A for variety release.

Replicated field trials of nine lines from breeding population A were planted in 3 locations: Davenport (WSU Wilke farm), LaCrosse, and Lind. Yield and data were taken mainly from the Davenport and Lind experiments, where stands were most uniform. Oil content was determined for three replications of each line. Other data taken included heading date and rate of stand establishment. A single line was selected for release. The yield and oil content were not significantly different than Calena in 2014. The line is homozygous (true breeding) for the HT gene.

Objective 2: Make and advance new breeding populations by crossing HT breeding lines to germplasm with higher yield potential or other useful traits.

In 2011-2013 we examined lines from the national germplasm center and private companies in replicated yield trials at Davenport and Pullman. Some of the accessions were heterogeneous and single plant selections were made. Five of the accessions yielded more than our check cultivar Calena. Crosses were made between some of our best HT breeding lines and many germplasm accessions in the last few years. Breeding populations we believe have the most potential are detailed as follows.

- Acc-31 x HT-494: Acc-31 is a Danish accession that has very high yield potential in the PNW. After crossing it to several HT lines and growing large F2 bulk populations in Pullman in 2014, we
selected 360 single plants from one of these populations for advancement. The HT line it was
crossed to is a sister line of the above line selected for release. These lines were advanced one
generation in the greenhouse and 360 F4-derived lines will be evaluated this summer.

- **Acc-3 x HT-494:** Acc-3 is the largest seeded accession we have identified and has average yield
  and oil content. This line was crossed to HT-494 to start developing larger seeded breeding
  lines. A large F3 derived bulk population was grown in Pullman in 2014 and individual plants
  with large seed pods and pod numbers were selected: genotypes with larger seed generally
  have larger seed pods. The seeds from these lines were then evaluated for size and 40 F4-
  derived lines were selected for field testing in plots in 2014.

- **CL-1914 x HT-494:** Some Washington growers are interested in lower erucic acid lines for food
  consumption and we reason that a food market for camelina will probably advance the adoption
  of the crop in the PNW. The CL-1914 was obtained from Chaofu Lu, Montana State University.
  It was derived from mutagenesis and has very poor agronomic performance. After crossing it to
  HT-494 and advancing it in the greenhouse, we grew a large F3 bulk population in Pullman in
  2014. Single vigorous plants with good seed yields were selected and advanced another
  generation in the greenhouse. In 2015, 48 F5-derived lines will be tested for yield and oil
  content in the field.

- **Other advanced lines:** Other lines in our replicated yield trials in 2015 include several derived
  from crosses between our SM4 mutant and two sustainable oils cultivars. Eight F5 derived lines
  from these crosses will be evaluated.

**Objective 3: Conduct genetic studies to determine future breeding aims.**

Genetic experiments have been underway to determine the limits in seed size in available germplasm
and to determine if this is a reasonable breeding goal, or if larger seed sizes are negatively correlated
with important traits like yield or oil content.

A program of **recurrent selection for large seed size** was initiated by intercrossing the three largest-
seeded germplasm accessions with three HT breeding lines. After self-fertilizing the F1s, F2 seed was
planted in plots in Pullman and sprayed with Beyond to select the HT trait. Roughly 100 individual
plants with large seed pods were visually selected in 2013 and the 12 largest seeded lines were then
planted and intercrossed in the greenhouse. Seed from this second cycle of intercrossing was again
planted in the greenhouse to generate seed for a second cycle of selection. These were grown in a large
bulk F2 population in 2014. In 2015, 27 F3 families with the largest seed size will be grown in replicated
plots. The families will be selected for both yield and seed size in 2015. The project will indicate what
type of progress can be made in increasing seed size by conventional recurrent selection from diverse
germplasm. Future breeding lines will likely be selected from this population.

In 2014, we completed construction of two large recombinant inbred populations that are both
segregating for seed size and oil content as well as some other performance related traits. Analysis of
these lines in field plots will begin this summer and will indicate whether there is an inverse **relationship
between seed size and oil content** as has been suggested in one report.

**Impact and Potential Outcomes:**

Cultivars grown in the PNW to date have generally consisted of selected European cultivars, and the
selections were not made in the PNW. There is great potential for breeding cultivars better adapted,
and higher yielding in the PNW by making and intercrossing selections under our environmental
conditions. High yielding HT cultivars will be advance the crop in the PNW because of the importance of
group 2 herbicides in our cropping systems. Cultivation of these varieties will eliminate much of the risk of camelina production for growers, especially those that are new to growing oilseed crops.

**Proposed Future Research/Extension for 2015/2016:**

We will establish a variety release committee for Camelina at WSU and begin the process of releasing the first HT variety.

We will continue to advance selections from HT breeding populations to develop higher yielding lines as well as lines with larger seed and lower erucic acid content. Many crosses with the HT trait have been made to increase the genetic diversity and agronomic potential of our HT breeding populations.

Preliminary analysis of our recurrent selection population for large seed size and our two mapping populations will shed light on what progress can be made breeding large seeded camelina varieties and whether this has a penalty in yield or oil content.