Brassica juncea, a Promising Biofuel Crop for the West Central Great Plains?

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OUTLINE

- Multidisciplinary work group for oilseed biofuels at CSU
- Why *Brassica* oilseeds for biofuel?
- Field trial results, 2008-2010
- Next steps for *Brassica* improvement

Collaborators, Multidisciplinary Work Group

Jerry Johnson
Agronomy

Abdel Berrada,
Agronomy

Alan Helm,
Weed Science

Dan Olsen,
Mechanical Engineering

Shawn Archibeque,
Animal Science

Catherine Keske,
Economics, Public Policy

Collaborators, Crop Genetics

Shusong Zheng
Post-doc

Jean-Nicolas Enjalbert,
PhD student

John McKay

Jack Mullen

Pat Byrne

USDA-AFRI
Biofuels Training Grant, 2009

Interdisciplinary training for four M.S. students with concentrations in

- Crop genetics
- Crop production
- Engine performance
- Economic analysis

Internships, teaching, Washington DC trip

3 Candidate Oilseed Species, all relatives of Canola

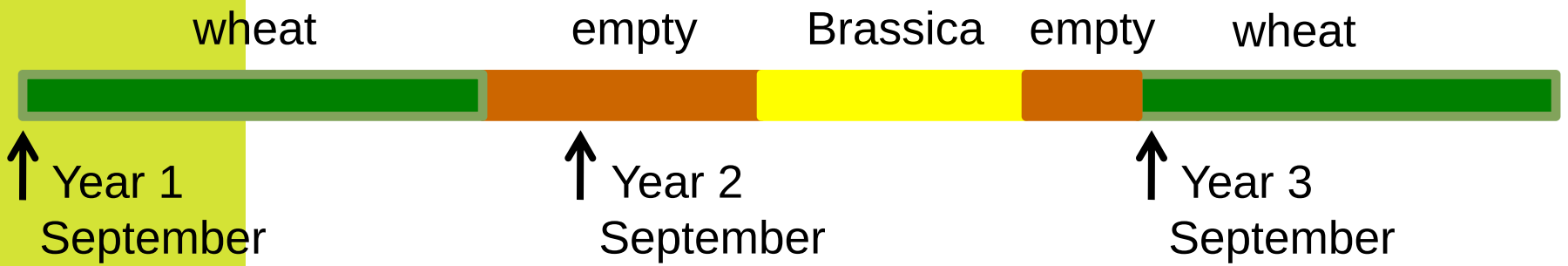
Brassica juncea, Indian brown mustard

Brassica carinata, Ethiopian mustard

Camelina sativa

Reasons for Exploring Oilseed Brassicas in Colorado

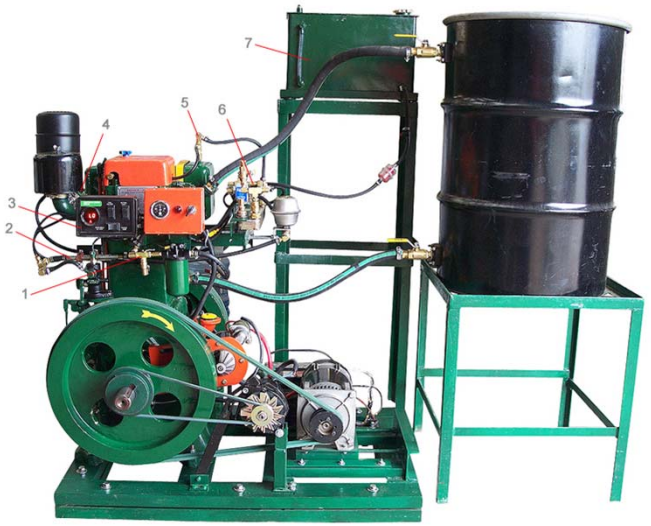
Brassicas fit into the winter wheat crop cycle.



Reasons for Exploring Oilseed Brassicas for Colorado

Extraction and conversion technologies exist now – not dependent on technical breakthroughs.

Straight vegetable oil (SVO) will help make farmers more energy independent; produce and use on-farm.



Reasons for Exploring Oilseed Brassicas for Colorado

A variety of products can be generated.

Seed → Crushing

Crushing → Animal feed

Crushing → Other co-products

Crushing → Meal

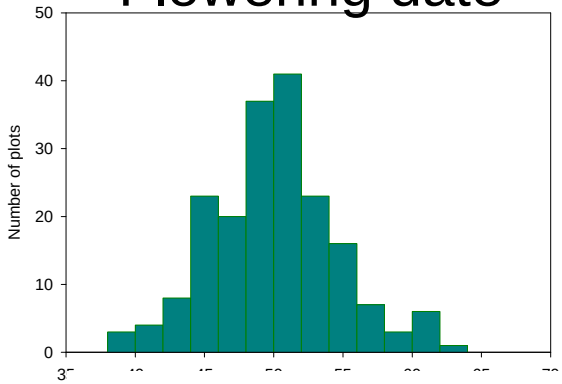
Crushing → Oil

Oil → Biodiesel
SVO
Food

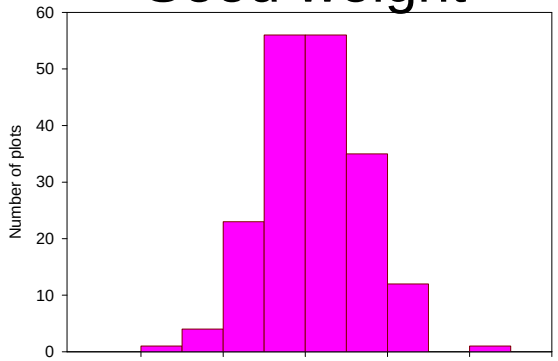
Reasons for Exploring Oilseed Brassicas in Colorado

Genetic variation exists among the Brassicas for maturity, heat and drought tolerance, seed yield, oil content, and oil profile.

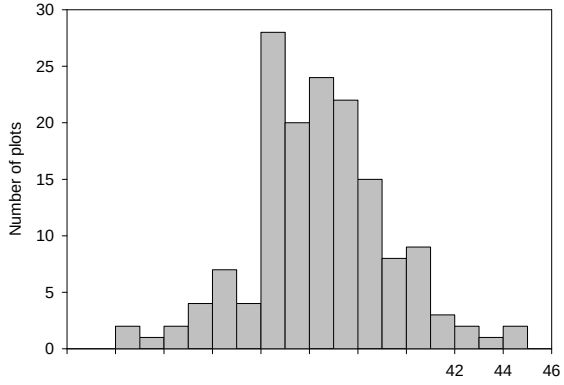
Flowering date



Seed weight



Seed oil content



Frequency distributions for 3 traits in 2008 rainfed trial.

Desirable Traits for Brassica Oilseed Crops

- Good emergence
- Life cycle fits crop rotation
- Uniform maturity, non-shattering
- Insect and disease resistant
- Tolerant to drought, heat, and cold
- Desirable oil profile for food and biofuel ("Double low"= glucosinolate <30 uMol/g and erucic acid<2%)

Brassica Studies, 2008

- We grew 229 accessions under both irrigated and dryland conditions:

  102 *Brassica juncea*

  39 *Brassica carinata*

  88 *Camelina sativa*.

- Plants were evaluated for maturity, agronomic traits, drought tolerance, and oil content.

Brassica juncea, Advantages

- Good emergence, except those with seed dormancy
- Appropriate maturity

  Life cycle, dry = 88 days;

  Life cycle, irrigated = 96 days
- Relatively drought tolerant
- Oil content

  Dry mean=36%, max=45%;

  Irrigated mean=37%, max=47%

Brassica juncea, Disdvantages

- Flea beetle damage at the seedling and flowering stages
- Aphid damage at the flowering and seed filling stages
- Stem lodging serious in some lines
- High glucosinolate concentrations

  Dry mean=128 uMol/g

  Irrigated mean=122 uMol/g
- However, low glucosinolate germplasm is available.

TRAIT MEANS FOR THREE SPECIES, 2008 EVALUATION

Irrigated	***B. juncea***	***B. carinata***	**Camelina**
Days to flower	51.2	60.4	50.7
Plant ht, cm	92.0	100.4	54.8
Biomass, g	5.4	6.1	2.8
Seed yield, g	1.3	1.1	0.6

Rainfed	***B. juncea***	***B. carinata***	**Camelina**
Days to flower	49.4	60.3	49.7
Plant ht, cm	65.7	51.7	38.8
Biomass, g	1.9	2.9	2.1
Seed yield, g	0.4	0.3	0.3

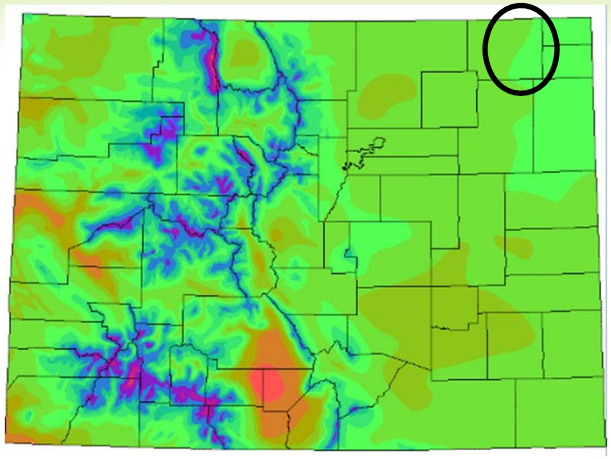
QUALITY IMPROVEMENT FOR *B. JUNCEA*

- Crosses made between 38 accessions and CBJ (a 'double low' juncea line from China)
- Crosses made between 60 accessions and DZJ (a 'double low' juncea line from Russia)

- F2's were evaluated at Iliff, CO in 2009 under two moisture regimes.
- F3's were evaluated at Iliff, CO in 2010 under two moisture regimes.

2009 Field Trial, Iliff CO

- 232 entries
  - 161 *B. juncea*
  - 69 *B. carinata*
  - 2 occurrences of the commercial canola hybrid V1035



- Full and limited irrigation treatments, 2 reps/treatment
- Unusually wet year with small differences between wet and dry treatments. Means of 4 reps presented.

Brassica juncea **Field Trial, Iliff, CO, 2009**

- Ample genetic variation observed among *Brassica juncea* for seed yield, oil and protein content, and glucosinolates.

	Yield (kg/ha)	% Oil	% Protein	Glucosinolates (uMol/g)
Juncea mean	981.9	36.1	31.2	102.8
Juncea min	213.6	28.3	25.3	39.7
Juncea max	1786.5	44.3	37.4	134.3
Carinata mean	763.9	31.8	35.4	119.2
V1035*	1149.4	43.8	29.0	11.0

* Commercial canola hybrid

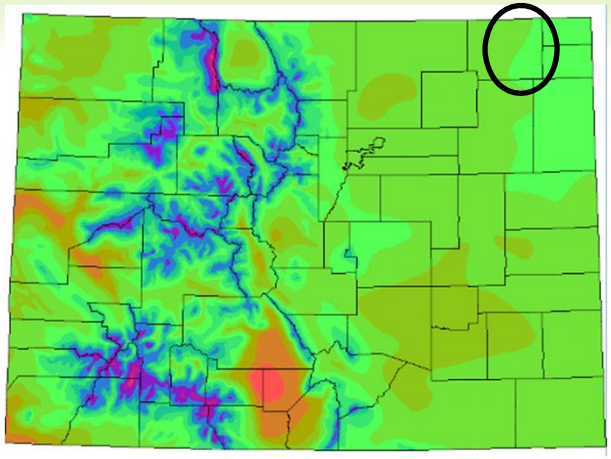
HETEROSIS FOR SEED YIELD

High-parent heterosis for seed yield averaged

- 20.5% in crosses of 38 accessions with the ‘double low’ inbred line CBJ
- 17.4% in crosses of 60 accessions with the ‘double low’ line DZJ

2010 Field Trial, Iliff CO

- 40 entries, based on 2009 results
  - 34 *B. juncea* (23 hybrids, 11 accessions)
  - 4 *B. carinata*
  - 2 occurrences of the commercial canola hybrid V1035



- Full and limited irrigation treatments, 2 reps/treatment
- Wet early season, hot and dry mid- to late season.

2010 Field Trial, Iliff CO

2010 Field Trial, Iliff CO, Wet Treatment

	Yield, kg/ha	200 seed wt, g	Plant ht, cm	Days to flower
Juncea mean	761.4	0.427	131.0	67.1
Juncea min	194.5	0.265	101.6	57.5
Juncea max	1123.5	0.610	156.2	71.5
Carinata mean	779.9	0.534	126.4	70.4
V1035*	989.0	0.503	111.1	67.0

* Commercial canola hybrid

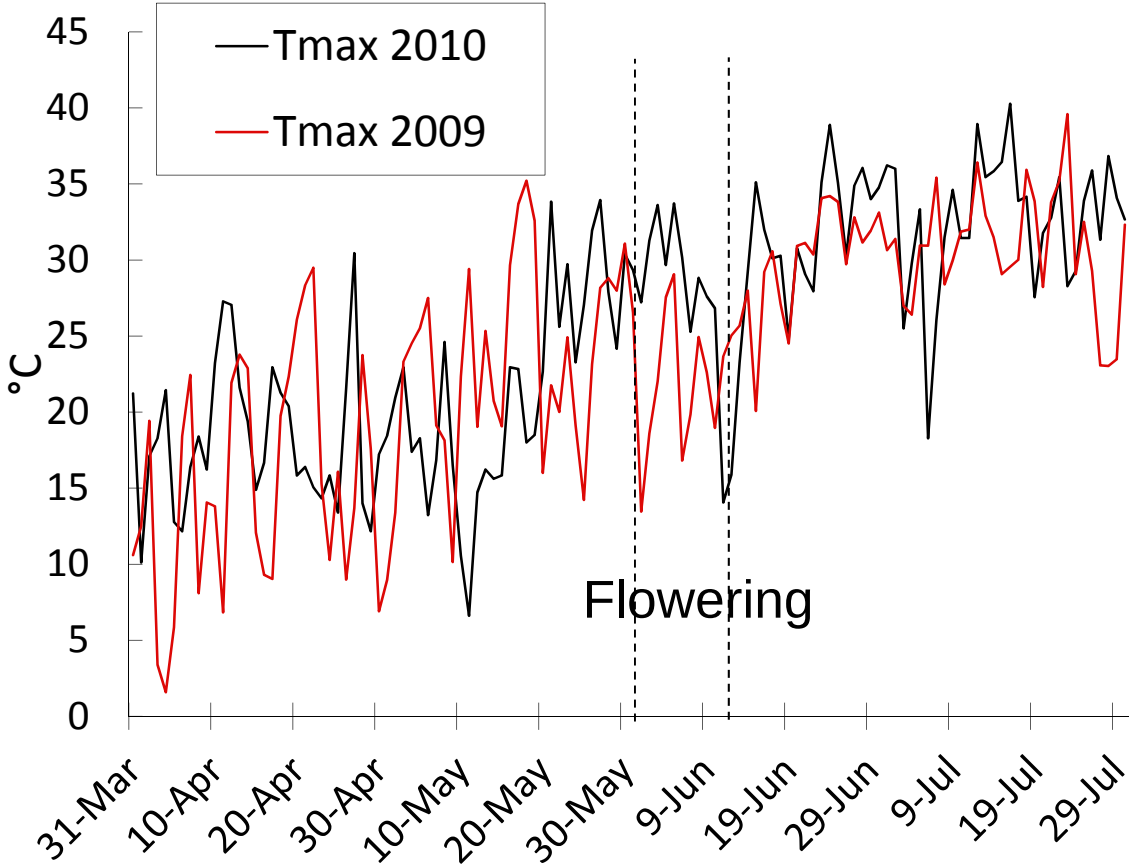
2010 Field Trial, Iliff CO, Dry Treatment

Yield reduction of 39% over the whole trial

	Yield, kg/ha	200 seed wt, g	Plant ht, cm	Days to flower
Juncea mean	474.3	0.392	129.2	67.3
Juncea min	162.0	0.255	110.5	59.0
Juncea max	923.5	0.585	151.1	71.5
Carinata mean	270.0	0.443	104.8	70.9
V1035*	900.0	0.511	106.1	67.0

* Commercial canola hybrid

Max temperatures, Akron, CO, 2009 and 2010



BEST PERFORMING *B. JUNCEA* ENTRIES, 2009 + 2010 DRY + 2010 WET

Entry ID	Rank sum	Origin
DZJ01/Jr-002	13	Russia
Jr-009	18	Russia
Jr-002	18	Russia
Jr-006	22	Russia
DZJ01/Jr-006	28	Russia
DZJ01/Jr-008	31	Russia
CBJ01/Jc-017	31	China
DZJ01/Jr-007	38	Russia
Jr-012	39	Russia
CBJ01/Jb-009	40	China/Bangladesh

Summary and Looking Forward

- An active interdiscplinary oilseeds work group has been established at Colorado State.
- Three years of field trials of *B. juncea* and *B. carinata* have been completed.
- Reasonable levels of heterosis were observed in crosses of accessions with two double low lines.

Summary and Looking Forward

- Germplasm from Russia, both accessions and crosses, had the best performance over 2 years. Additional field trials are planned.
- Engine performance and emissions studies in relation to different oil profiles is underway.
- For the future:
  - Animal feeding trials
  - Economic analysis
  - Environmental assessment
  - Strengthen collaborations with domestic and international collaborators.

ACKNOWLEDGEMENTS

Superclusters™
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