Variation in Water Stress of 12 Brassica Genotypes Across Different Environments Based on δ ^{13}C Signature

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Introduction

Hyrdrotreated renewable jet fuel (HRJ) has been demonstrated in military and commercial aircraft, but large-scale production has been hindered by feedstock costs. Seed oil from several Brassica crops can serve as feedstock for HRJ, but the best agronomic and economic choice may differ with environment. Feedstock production is mainly being targeted for the small grain growing regions of the western U.S., where water availability is by far one of the most limiting factors for crop production.

The 'Great Green Fleet'

U.S. Navy ships and planes off the coast of Hawaii participate in the U.S. Navy's Rim of the Pacific Exercises (RIMPAC) Great Green Fleet (GGF) demonstration in Honolulu, HI. USDA Report 10/11/16

Objective

In the present study, δ ^{13}C signature of seed was used as a surrogate to determine susceptibility to water stress of several Brassica oilseed crops grown across the western U.S. This is part of a larger effort to determine the best agronomic and economic choice(s) of Brassica oilseed crop(s) for the western U.S. as feedstock for HRJ production.

Methods

- The field study was conducted in 2014 across seven locations that ranged from the western Corn Belt, across the north and central Great Plains to the Pacific Northwest (see Fig. 1).
- The experimental design at each location was a RCBD with four replications.
- Twelve Brassica genotypes representing six species were grown under rain-fed condition (listed in Table 2).
- Seeding rates were based on seed number and kept constant across sites at approximately 1.25 million seeds ha^{-1} for all genotypes except camelina, which was sown at 3.95 million seeds ha^{-1}.
- Recommended cultural practices including fertilizer application were followed for all genotypes. Planting and harvest dates are shown in Table 1. Harvest date varied 2 to 3 weeks depending on genotype and the dates given in Table 1 are for the latest harvest at each location.
- Approximately 4 g of clean seed (4 reps/cv/site) was ground to fine powder and a portion sent to a lab at South Dakota State Univ. for δ ^{13}C analysis using a Europa 20-20 ratio mass spectrometer.
- Data were analyzed with a Mixed Model using SAS.

Brassica field plots in Morris, MN 2014.

Results

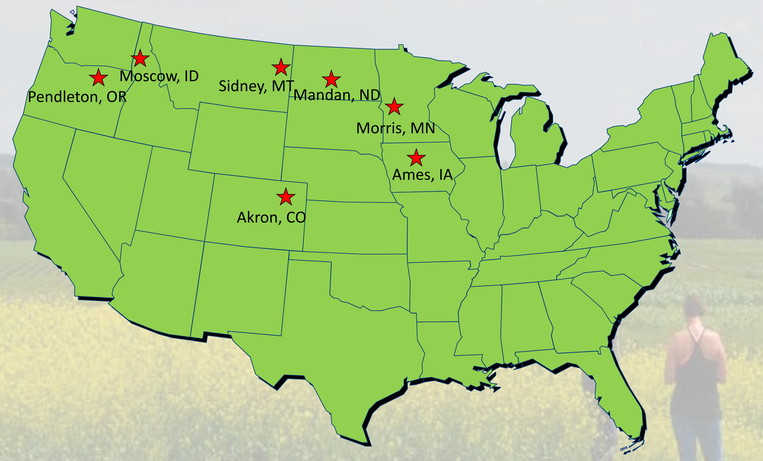

Figure 1. U.S. map showing the locations of the experimental sites

Table 1. Mean δ ^{13}C by location averaged across all genotypes in 2014. Accumulated precipitation between planting and final harvest is shown.

Location	δ ^{13}C (‰)	Planting Date	Harvest Date	Accum. Precip.
Pendleton, OR	-24.8 A	Apr 1	Jul 23	92 mm
Akron, CO	-25.0 A	Apr 11	Jul 23	251 mm
Sidney, MT	-25.8 B	Apr 25	Aug 1	148 mm
Moscow, ID	-26.9 C	May 2	Aug 29	88 mm
Mandan, ND	-28.2 D	May 22	Sept 15	293 mm
Ames, IA	-28.5 DE	Apr 18	Aug 12	512 mm
Morris, MN	-28.7 E	May 6	Aug 26	363 mm

- δ ^{13}C averaged across all genotypes by location tended to correlate with dryness of environment, increasing from east to west (Fig. 1 & Table 1) indicating greater water stress.

Table 2. Mean δ ^{13}C by genotype averaged across all seven locations.

Cultivar	Species	δ ^{13}C (‰)
080814 EM	*Brassica carinata*	-26.3 A
Gem	*Brassica napus*	-26.4 A
Pacific gold	*Brassica juncea*	-26.5 AB
SC 28	*B. napus*	-26.6 ABC
Eclipse	*Brassica rapa*	-26.6 ABCD
Idagold	*Sinapis alba*	-26.9 BCDE
AAC A110	*B. carinata*	-26.9 BCDE
Tilney	*S. alba*	-27.0 CDE
DK3042 RR	*B. napus*	-27.0 CDE
Oasis	*B. juncea*	-27.1 DE
Invigor L130	*B. napus*	-27.2 E
CO46	*Camelina sativa*	-27.9 F

- δ ^{13}C signature consistently indicated that 080814 EM *B. carinata* sustained the most stress, while CO46 camelina suffered the least.
- Mean separation of δ ^{13}C between most genotypes was small.

Table 3. Mean δ ^{13}C and seed yield by genotype averaged across the four most stressful environments, OR, CO, MT, and ID in 2014.

Cultivar	Species	δ ^{13}C (‰)	Yield (kg ha^{-1})
080814 EM	*Brassica carinata*	-24.9 A	1075
Gem	*Brassica napus*	-25.1 AB	883
SC 28	*B. napus*	-25.1 ABC	1066
Eclipse	*Brassica rapa*	-25.3 ABCD	747
Pacific gold	*Brassica juncea*	-25.5 BCDE	1073
DK3042 RR	*B. napus*	-25.5 BCDE	1255
AAC A110	*B. carinata*	-25.6 CDEF	1002
Invigor L130	*B. napus*	-25.7 DEF	1330
Oasis	*B. juncea*	-25.8 EF	971
Tilney	*Sinapis alba*	-25.9 EF	944
Idagold	*S. alba*	-26.0 F	878
CO46	*Camelina sativa*	-27.0 G	1072

- 080814 EM *B. carinata,* which had the highest δ ^{13}C (greatest stress) was also the latest to mature at all sites.
- CO46 camelina had significantly the lowest δ ^{13}C and along with the *Sinapis alba* genotypes was the earliest to mature at all study sites.

Table 4. Mean δ ^{13}C and seed yield of 080814 EM *B. carinata* by location.

Location	δ ^{13}C (‰)	Yield (kg ha^{-1})
Akron, CO	-23.6	936
Pendleton, OR	-24.2	1082
Sidney, MT	-25.4	1421
Moscow, ID	-26.6	860
Mandan, ND	-28.3	2190
Morris, MN	-28.9	1980

- 080814 EM *B. carinata* suffered less stress in the eastern region of the study.
- Mean seed yield correlated well with δ ^{13}C except for the ID site.

Honey bee visiting a canola flower.

Summary

- Generally, δ ^{13}C was a good indicator of water stress by location for the Brassica genotypes studied.
- When averaged across locations, however, there was not necessarily a good correlation between δ ^{13}C and the highest/lowest yielding genotypes indicating other factors besides water stress (e.g., genetics, weeds, disease and insects) were interacting to affect yield and perhaps δ ^{13}C signature.
- Camelina and other early maturing genotypes (e.g., *Sinapis alba*), were least susceptible to water stress and may be good HRJ feedstock choices for drought-prone areas in the western U.S.
- *Brassica carinata* and other longer maturing genotypes, which tended to be more susceptible to water stress, may be better suited for the Northern Plains and Corn Belt regions that generally have greater growing season moisture availability.

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