Title: Growing Biofuels in Western Washington

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Graduate students: None

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Background: It is not known whether biofuel crops currently grown for oil production (including, canola, flax, sunflower, mustard, sunflower, safflower, meadowfoam, and camelina), can be economically produced in western Washington. Previous testing at Mount Vernon has shown that, while meadowfoam, safflower, and sunflower can be grown in the region, their yield or other production factors likely will not allow them to be produced profitably by growers, so current research is aimed at canola, mustard, and camelina. Simple agronomic production guidance is scarce for these crops in this region; therefore, research thus far has focused on determining seeding dates, seeding rates, fertilizer requirements, harvest factors (seed moisture, maturity, etc.), and other production factors. Testing from 2008-2010 at WSU Puyallup has centered on use of organic fertilizers on certified organic land, species, and seeding dates, while testing at WSU Mount Vernon NWREC has centered on species, seeding dates, seeding rates, and fertilizer rates.

Objectives: The objective of this research is to determine optimal production strategies for various oilseeds in western Washington. Specific trials include:

1. Conduct fertilization trials using biosolids with fall and spring canola, yellow mustard, and camelina on organic ground at WSU Puyallup.

2. Conduct seeding rate and fertilizer rate trials with yellow mustard and camelina at WSU Mount Vernon NWREC.

These trials will help to determine whether these crops may be profitably produced under western Washington conditions as well as identifying production obstacles that remain to be overcome.

1A. Fall canola trial, WSU Puyallup. Fall canola (*Brassica napus,* cv. 'Athena') and camelina (*Camelina sativa,* cv. 'Celine') was seeded at approximately 8 lbs/acre into 10- by 20-ft plots September 3, 2010. Plots were treated with two sources of biosolids at two rates: Soundgro biosolids at 1 or 2 dry tons/acre (corresponding to an estimated 117 or 236 lbs total N/acre, respectively), or Everett biosolids at 6 or 12 dry tons/acre (corresponding to an estimated 213 or 426 lbs total N/acre, respectively); products were mechanically incorporated prior to seeding. Seed was sprinkled on the surface of the soil as appropriate, then raked by hand to shallowly incorporate. Percent crop and weed cover was visually estimated September 27, October 20, November 30, 2010 and January 31 and April 23, 2011. Crop plants within a 12- by 20-inch quadrat were clipped at ground level July 21. Excess stem material was trimmed off each plant, and remaining upper stems and racemes were placed into paper grocery bags and then stored in a greenhouse at WSU Mount Vernon NWREC for slow drying and seed ripening to

occur (maximum daytime temperatures did not exceed 85 F during the drying process). After approximately three weeks of drying, seed was threshed by hand, passed over screens to remove large chaff, and freed of fine chaff and dust using a blower-style seed cleaner. Seed weight for each sample was then recorded. Yield data were analyzed using a general linear models procedure and means were separated using Fisher's Protected LSD at the P = 0.05 level. The design was a randomized complete block with three replicates.

1B. Spring oilseed trial, WSU Puyallup. Spring canola ('Sunrise' and 'Clearwater') and spring rapeseed ('Gem' and 'Sterling') (all *Brassica napus*), 'IdaGold' yellow mustard (*Sinapis alba*) and 'Celine' camelina were seeded April 23, 2011 at WSU Puyallup. All oilseed crops were seeded at 8 lbs/acre and then raked by hand to shallowly incorporate seed. Plots (10- by 20-ft) were treated with two sources of biosolids as described above for winter canola. Crop plants within a 12- by 20-inch quadrat were counted and clipped at ground level August 11 and processed as described above for winter canola. Yield data were analyzed using a general linear models procedure and means were separated using Fisher's Protected LSD at the P = 0.05 level. The design was a randomized complete block with three replicates.

2. Spring oilseed trial, WSU Mount Vernon NWREC. 'IdaGold' yellow mustard and 'Celine' camelina were seeded June 3, 2011 at WSU Mount Vernon NWREC. Crops were seeded at 5 or 8 lbs/acre using a 6-row cone seeder. Plots (10- by 30-ft) were treated with urea (46-0-0) and mechanically incorporated the day prior to seeding; rates were equivalent to 0, 50, or 100 lbs N/acre. Crop and weed biomass was sampled August 3. Crop plants and weeds within a 12- by 20-inch quadrat were clipped at ground level, separated, then dried at 50°C for 48 hours and weighed. Crop plants were harvested using a plot combine September 21. After drying in a seed dryer for three days at 70°C, seed was threshed by hand, passed over screens to remove large chaff, and freed of fine chaff and dust using a blower-style seed cleaner. Seed weight for each sample was then recorded. Yield data were analyzed using a general linear models procedure and means were separated using Fisher's Protected LSD at the P = 0.05 level. The design was a randomized complete block with four replicates.

Results and Discussion:

1A. Fall canola trial, WSU Puyallup. Initial growth of canola was excellent by October, with cover ranging from 78 to 92% (Table 1). Lower means were associated with Soundgro and Everett at the 6 ton/a rate. Crop cover had decreased by April ranging from 43 to 77%, with lower means again resulting from Soundgro, or with Everett at the 6 ton/a rate. Camelina cover was only half that of the canola in October, with Everett resulting in almost twice the cover as from Soundgro. By January, camelina had winter-killed. Weed cover was minimized by canola fertilized with Everett at 12 tons/a in October and November (8 and 7%, respectively) (Table 2). In general, low N fertilizer resulted in higher weed populations by April, likely because the canola crop was less vigorous.

Canola yield similarly closely followed N application rate (Table 3). Some seed was lost prior to harvest due to seed pod shatter, so these yields are lower than would otherwise be expected. Crop stand at harvest did not differ by nutrient source. Because camelina winter-killed, no camelina seed was produced in this trial.

Table 1. Percent crop cover in fall-seeded crops at WSU Puyallup (2010-11).

Nutrient source	Rate[1] dry tons/a	Crop	9/27/10 %	10/20/10 %	11/30/10 %	1/31/11 %	4/23/11 %
Everett	6 (213)	Canola	28	85	82	73	60
Everett	12 (426)	Canola	32	92	93	80	77
Soundgro	1 (117)	Canola	32	78	78	60	43
Soundgro	2 (236)	Canola	27	80	82	72	60
Everett	6 (213)	Camelina	23	42	27	0	0
Everett	12 (426)	Camelina	20	40	40	0	0
Soundgro	1 (117)	Camelina	12	28	18	0	0
Soundgro	2 (236)	Camelina	12	23	15	0	0

[1]Soundgro biosolids equivalent to an estimated 117 or 236 total lbs N/acre; Everett biosolids equivalent to an estimated 213 or 426 total lbs N/acre.

Table 2. Percent weed cover in fall-seeded crops at WSU Puyallup (2010-11).

Nutrient source	Rate[1] dry tons/a	Crop	9/27/10 %	10/20/10 %	11/30/10 %	1/31/11 %	4/23/11 %
Everett	6 (213)	Canola	40	15	18	20	35
Everett	12 (426)	Canola	40	8	7	12	12
Soundgro	1 (117)	Canola	45	20	22	35	57
Soundgro	2 (236)	Canola	37	20	18	23	40
Everett	6 (213)	Camelina	42	58	72	95	100
Everett	12 (426)	Camelina	50	60	60	95	100
Soundgro	1 (117)	Camelina	42	68	82	100	100
Soundgro	2 (236)	Camelina	45	75	83	98	100

[1]Soundgro biosolids equivalent to an estimated 117 or 236 total lbs N/acre; Everett biosolids equivalent to an estimated 213 or 426 total lbs N/acre.

Table 3. Canola stand and oilseed yield (2011).

Nutrient source	Rate[1] dry tons/a	Crop stand[2] plants/quadrat	Yield[2] lbs/a
Everett	6 (213)	8.7	2624 ab
Everett	12 (426)	10.3	3045 a
Soundgro	1 (117)	7.3	1436 b
Soundgro	2 (236)	6.3	2317 ab

Means within a column followed by the same letter or not followed by a letter are not significantly different ($P < 0.05$). Plots were seeded and shallowly incorporated September 3, 2010.

[1]Soundgro biosolids equivalent to an estimated 117 or 236 total lbs N/acre; Everett biosolids equivalent to an estimated 213 or 426 total lbs N/acre.

[2]Crop stand sampled and yield collected July 21, 2011.

1B. Spring oilseed trial, WSU Puyallup. In 2010, yield was significantly greater for canola and rapeseed (from about 2900 to 4300 lbs/acre) than for mustard or camelina (about 1900 and 1300 lbs/a, respectively) (Table 4). In 2011, all cultivars produced similar amounts of seed, ranging from 2834 to 4698 lbs/a. Although yield did not significantly differ by fertilizer regime either year (Table 5), there was a trend for Soundgro to result in higher yields than Everett on a pound-for-pound basis, particularly in 2010. The higher application rates in 2010 also tended to result in more seed production than did the lower rates, although this was less clear in 2011.

Table 4. Seed yield by cultivar.

Cultivar/species	2010 Yield[1] lbs/a	2011 Yield[1] lbs/a
Sunrise canola	3511 ab	3852
Gem rapeseed	2892 abc	4698
Sterling rapeseed	3100 ab	3753
Clearwater canola	4281 a	3431
Celine camelina	1279 c	3094
IdaGold mustard	1923 bc	2834

Means within a column followed by the same letter or not followed by a letter are not significantly different ($P < 0.05$). Fertilizer was applied and incorporated April 22 and plots were seeded April 23, 2010, and on the same dates in 2011.

[1]Oilseed yield samples collected August 30, 2010 and August 11, 2011.

Table 5. Seed yield under different fertilizer regimes.

Nutrient source	Rate[1] dry tons/a	2010 Yield[3] lbs/acre	2011 Yield[3] lbs/acre
Everett biosolids	6 (213)	2851	3912
Everett biosolids	12 (426)	3190	3830
Soundgro biosolids	1 (117)	2657	3761
Soundgro biosolids	2 (236)	3017	3047

Means within a column followed by the same letter or not followed by a letter are not significantly different ($P < 0.05$). Fertilizer was applied and incorporated April 22 and plots were seeded April 23, 2010 and on the same dates in 2011.

[1]Soundgro biosolids equivalent to an estimated 117 or 236 total lbs N/acre; Everett biosolids equivalent to an estimated 213 or 426 total lbs N/acre.

[3]Oilseed yield samples collected August 30, 2010 and August 11, 2011.

2. Spring oilseed trial, WSU Mount Vernon NWREC. In 2010, crop biomass at two months after seeding was greatest (10,341 lbs/a) with yellow mustard seeded at 8 lbs/acre and fertilized with 100 lbs N/acre (Table 6). Mustard also produced about 7200 to 8100 lbs/acre of biomass when seeded at 5 lbs/acre and fertilized at 50 or 100 lbs N/acre, or when seeded at 8 lbs/acre and fertilized with 50 lbs N/acre. A comparable level of biomass (about 6000 to 7000 lbs/acre) was produced with camelina seeded at 5 lbs/acre and 100 lbs N/acre or seeded at 8 lbs/acre and fertilized with 50 or 100 lbs N/acre. In general, the higher the seeding and fertilizer rate, the greater the biomass production for either crop, although yellow mustard tended to produce more biomass at comparable rates than did camelina. There were no clear trends due to seeding rate or fertility in 2011, however, with all mustard plots outproducing camelina 3- to 4-fold. There were no differences among mustard plots or among camelina plots due to seeding or fertilizer rate.

In 2010, weed biomass at two months after seeding did not differ between crop species, N rate, or crop seeding rate (Table 6). Although not statistically significant, there was a trend toward greater weed biomass with camelina than with mustard. It also appeared that when no N was applied to either species, the 8 lbs/acre seeding rate resulted in much more weed suppression than did the 5 lbs/acre seeding rate. In 2011, weed biomass was up to 10 times greater in camelina than in mustard. Unlike in 2010, there was a trend toward higher weed biomass at higher seeding rates.

In 2010, yield of yellow mustard did not differ by fertilizer or seeding rate (Table 6); camelina yield also did not differ by treatments. In general, mustard outyielded camelina, with ranges from about 3400 to

5400 lbs/acre for mustard compared to about 1600 to 3100 lbs/acre for camelina. In 2011, all mustard plots outyielded camelina, except for mustard seeded at 5 lbs/acre and either not fertilized or fertilized at 50 lbs N/acre when compared to camelina at 5 lbs/acre with no added N.

Table 6. Crop and weed biomass and oilseed yield under different fertilizer and seeding rates.

Species	Fertilizer rate	Seeding rate	Crop biomass[1]		Weed biomass[1]		Yield[2]	
			2010	2011	2010	2011	2010	2011
	lbs N/a	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a
Camelina	0	5	2758 e	1594 b	1214	1522 bcd	1991 cd	752 c
Camelina	0	8	2384 e	1092 b	651	2384 bc	3102 bcd	349 d
Camelina	50	5	5070 cd	819 b	836	2025 bcd	2864 cd	406 d
Camelina	50	8	6032 bc	948 b	730	3246 ab	1629 d	259 d
Camelina	100	5	6937 bc	991 b	725	1824 bcd	2462 cd	362 d
Camelina	100	8	6248 bc	934 b	1053	4323 a	3368 a-d	347 d
Mustard	0	5	3418 de	3519 a	330	474 d	3723 a-d	932 bc
Mustard	0	8	5271 cd	4065 a	126	531 d	3770 abc	1143 ab
Mustard	50	5	7253 bc	4022 a	454	431 d	5015 ab	950 bc
Mustard	50	8	7655 b	3849 a	481	560 cd	3886 abc	1175 ab
Mustard	100	5	8072 b	3375 a	490	531 d	5199 ab	1040 ab
Mustard	100	8	10341 a	4122 a	247	517 d	5409 a	1237 a

Means within a column followed by the same letter or not followed by a letter are not significantly different ($P < 0.05$). Fertilizer was applied and incorporated May 6, 2010 and June 2, 2011; plots were seeded May 7, 2010 and June 3, 2011.

[1]Plant biomass estimated July 9, 2010 and August 3, 2011.

[2]Oilseed yield samples collected September 30, 2010 and September 21, 2011.

Impact/Potential Outcomes: Camelina and yellow mustard biofuel plots were featured on the WSU Mount Vernon NWREC field tour July 14, 2011 with 150 people attending.

Publications:

Miller, T.W., C.G. Cogger, A.I. Bary, C.R. Libbey, and E.A. Myhre. Growing biofuel crops in western Washington. 2010. Proceedings, Bioenergy Research Symposium, Seattle, WA.

A journal article with this two-year study, with an accompanying extension fact sheet, is being prepared.

Proposed Future Research/Extension: The 2012 spring trials will be conducted at WSU Mount Vernon NWREC. Because of poor seeding conditions in 2011, oilseed performance wasn't as good as in 2010, so this trial will be repeated in 2012. 'IdaGold' yellow mustard and 'Celine' camelina will be seeded at 5 and 8 lbs/acre into plots were treated with urea and mechanically incorporated the day prior to seeding at rates equivalent to 0, 50, and 100 lbs N/acre.