The Impact of Nitrogen Use Efficiency on Greenhouse Gas Emission in Canola Biodiesel Feedstock Production

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Nitrogen Systems: Policy-oriented Integrated Research and Education
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Objectives

1. **Determine the impact of NUE on GHG emission from PNW canola.**
2. **Determine the impact of nitrous oxide emission estimates for three canola production zones in eastern WA on GHG emission.**
3. **Determine how canola production regions in Washington State compare to national averages for GHG mitigation.**

Methods

Land area in production for three agroecological zones (AEZs) – Washington State University's Geospatial Research Lab (Figure 1 and Table 1).

Estimates for the probable maximum land area in canola production were determined for each AEZ based on likely future rotations.

Average yield was estimated to determine recommend N fertilizer application (personal communication).

N fertilizer rate range was the recommended rate and 25% of the recommended rate (Franzen and Lukach, 2007). Reduced N rate is based on the authors' unpublished NUE data.

Nitrous oxide flux rates ranges (Haile-Mariam et al., 2008; Dusenbury et al., 2008).

Fertilizer manufacture and transportation and canola production CO_2 emission (West and Marland, 2002).

Sensitivity analysis was conducted holding values static and varying N fertilizer input and N_2O emission rates each individually(Figure 2).

Figure1: Eastern Washington rainfall gradient and agroecological zones circled.

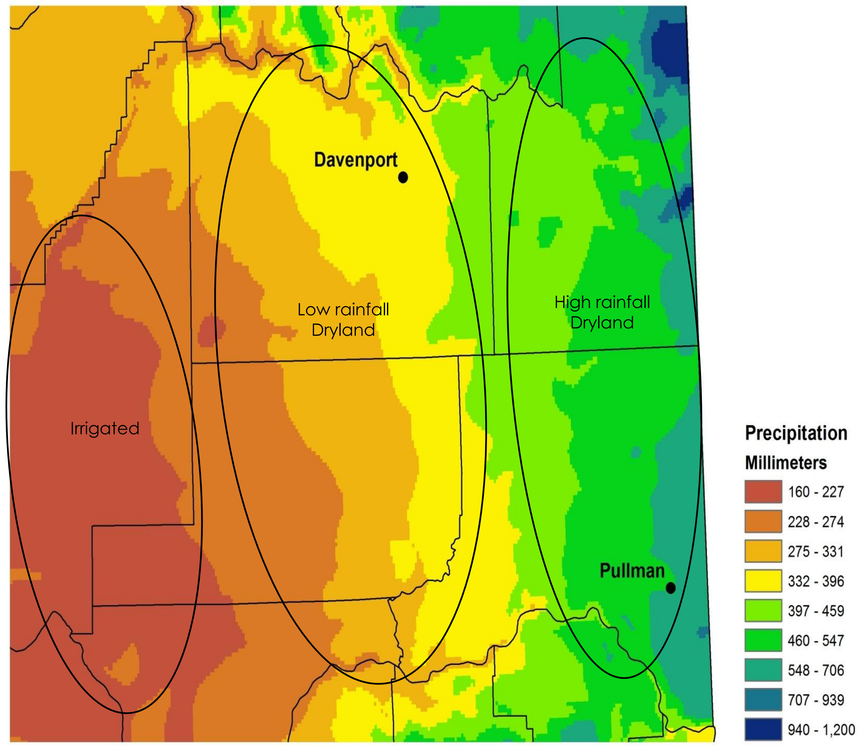

Figure 2: 20-Year cumulative greenhouse gas (CO_2 and N_2O) emissions for canola feedstock biodiesel in three eastern Washington agroecological zones. Inputs other than nitrogen fertilizer and irrigation are assumed to be uniform.

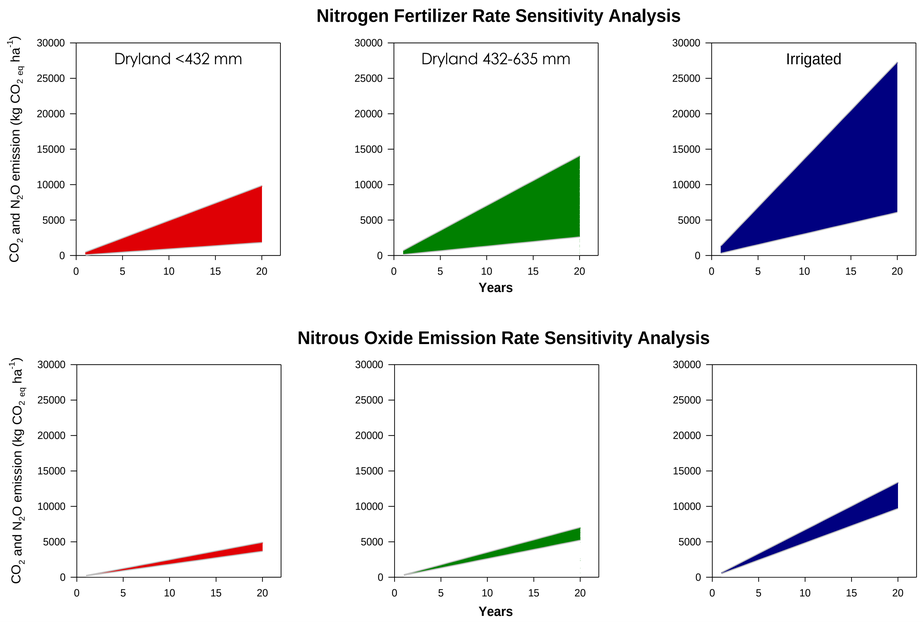

Figure 3: Net CO_2 equivalent balance as a result of canola production CO_2 and N_2O emissions (debit) and biodiesel combustion CO_2 emissions (credit) for three agroecological zones in eastern Washington.

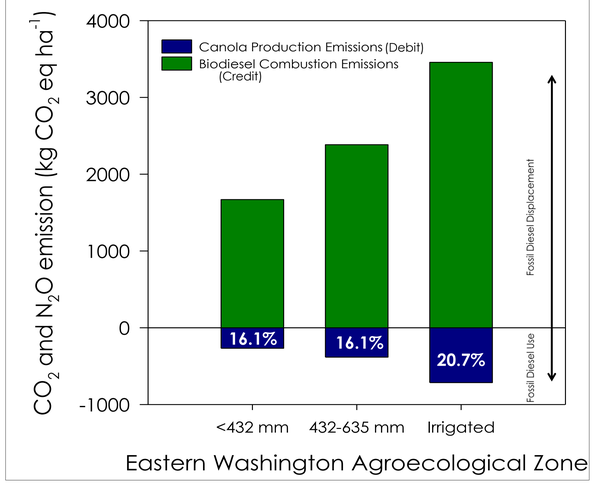

Figure 4: 30-Year cumulative annual greenhouse gas emissions EPA fossil diesel, EPA canola biodiesel, and simulated canola produced in eastern Washington. Partially adapted from EPA (2010).

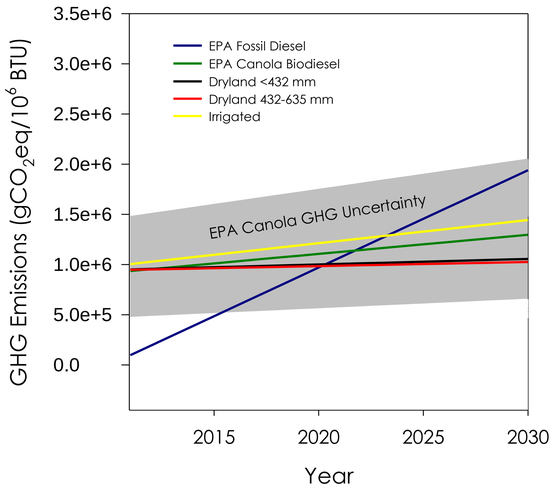

Table1: Parameter estimates and model outputs for GHG emissions (CO_2 and N_2O) sensitivity analysis for canola feedstock biodiesel. The top section identifies parameters that remain static; the middle section contains parameters for variable N fertilizer application and corresponds to the top three graphs in Figure 1; and the bottom section contains parameters for variable nitrous oxide emission rate and corresponds to the bottom three graphs in Figure 1.

Parameter Estimates	-----Agroecological Zone-----		
	<432 mm	432-635 mm	Irrigated
Area (ha)	236669	178781	40310
Yield (kg ha^{-1})	1569	2242	3250
Irrigation CO_2 (kg C ha^{-1})	-	-	266
N Fert Prod CO_2 (kg C Mg^{-1})	814	814	814
N Fert Transport CO_2 (kg C Mg^{-1})	43.5	43.5	43.5
Biodiesel Produced(l ha^{-1})	661	944	1368
GHG emissions from biodiesel (kg CO_2 eq ha^{-1})	1669	1898	3457

Variable N fertilizer input		-----Agroecological Zone-----		
Parameter	N Fert. Range	<432 mm	432-635 mm	Irrigated
N rate (kg ha^{-1})	***Low***	***27.5***	***39.2***	***56.9***
	High	***110***	***157***	***228***
N applied (Mg)	Low	6499	7013	2293
	High	25996	28054	9172
N Fert Prod CO_2 (Mg CO_2)	Low	19400	20935	6844
	High	77599	83741	27378
N Fert Transport CO_2 (Mg CO_2)	Low	1037	1119	366
	High	4146	4475	1463
N_2O emissions rate (% of applied N)		0.26	0.26	0.58
N_2O emissions (Mg N_2O)	Low	16.6	17.9	13.2
	High	66.3	71.5	13.2
CO_2 eq of N_2O emissions (Mg CO_2 eq)	Low	4939	5330	3929
	High	19754	21318	15716
GHG emissions (Mg CO_2 eq)	Low	25375	27384	14124
	High	101500	109534	47541
GHG emissions (kg CO_2 eq ha^{-1})	Low	107	153	350
	High	429	613	1179

Variable N_2O emissions	N_2O Flux	-----Agroecological Zone-----		
Parameter	Range	<432 mm	432-635 mm	Irrigated
N rate (kg ha^{-1})		69	98	142
N applied (Mg)		16245	17531	5731
N Fert Prod CO_2 (Mg CO_2)		48492	52331	17109
N Fert Transport CO_2 (Mg CO_2)		2591	2796	914
N_2O emissions rate (% of applied N)	***Low***	***0.06***	***0.06***	***0.30***
	High	***0.45***	***0.45***	***0.85***
N_2O emissions (Mg N_2O)	Low	9.75	10.5	17.2
	High	41.4	44.7	33.0
CO_2 eq of N_2O emissions (Mg CO_2 eq)	Low	2905	3135	5124
	High	21785	23509	14518
GHG emissions (Mg CO_2 eq)	Low	53988	58261	24122
	High	72868	78636	33516
GHG emissions (kg CO_2 eq ha^{-1})	Low	228	326	598
	High	308	440	832

References

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