Impact of nitrogen use efficiency on greenhouse gas emission in canola biodiesel feedstock production

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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 Reduced N rate is based on the authors' unpublished NUE data.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.

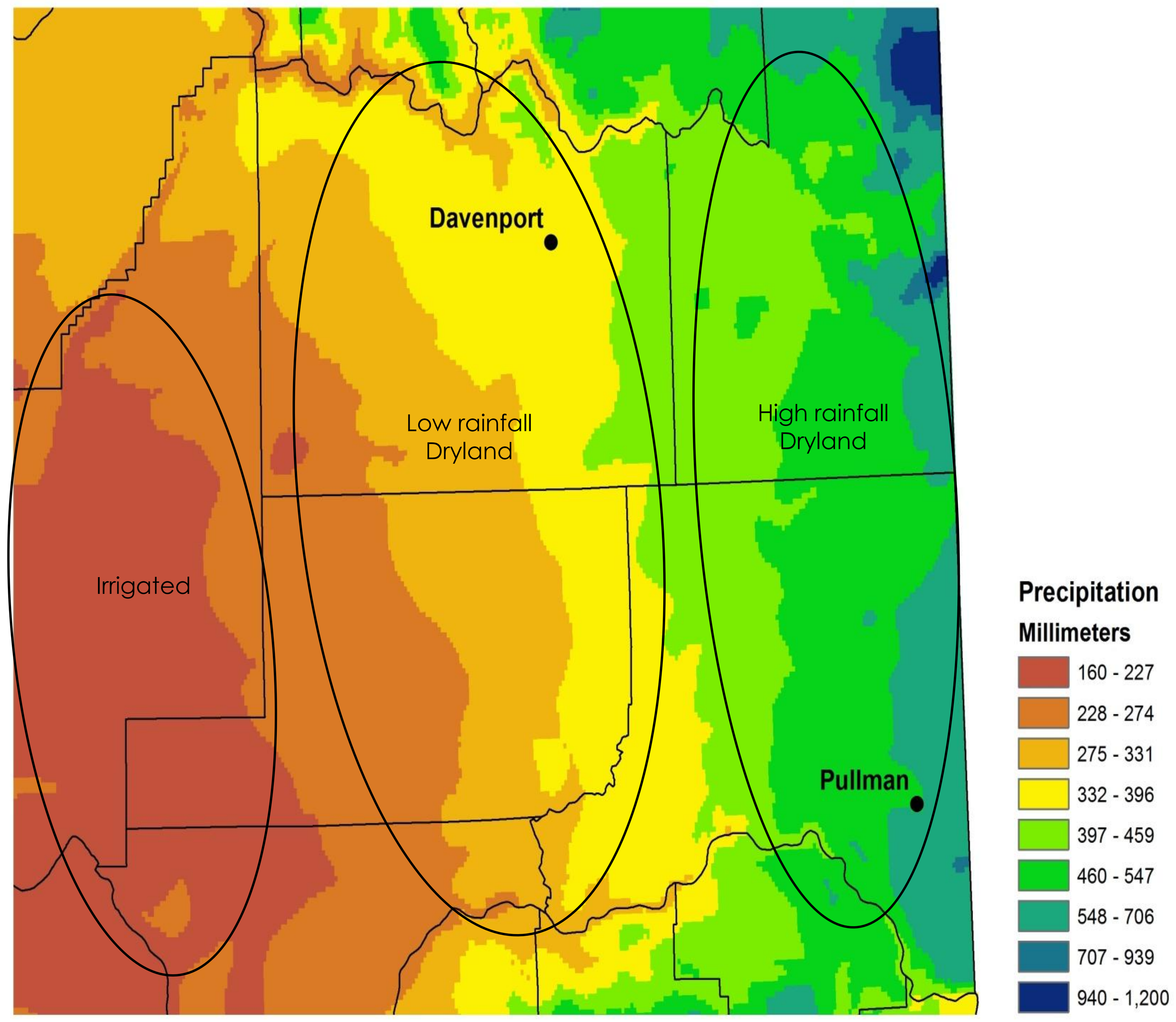


Figure2: 20-Year cumulative greenhouse gas (CO_2 and N_2O) emissions for canola feedstock biodiesel in three eastern Washington agroecological zones. Inputs other than nitrogen fertilizer and irrigation are assumed to be uniform.

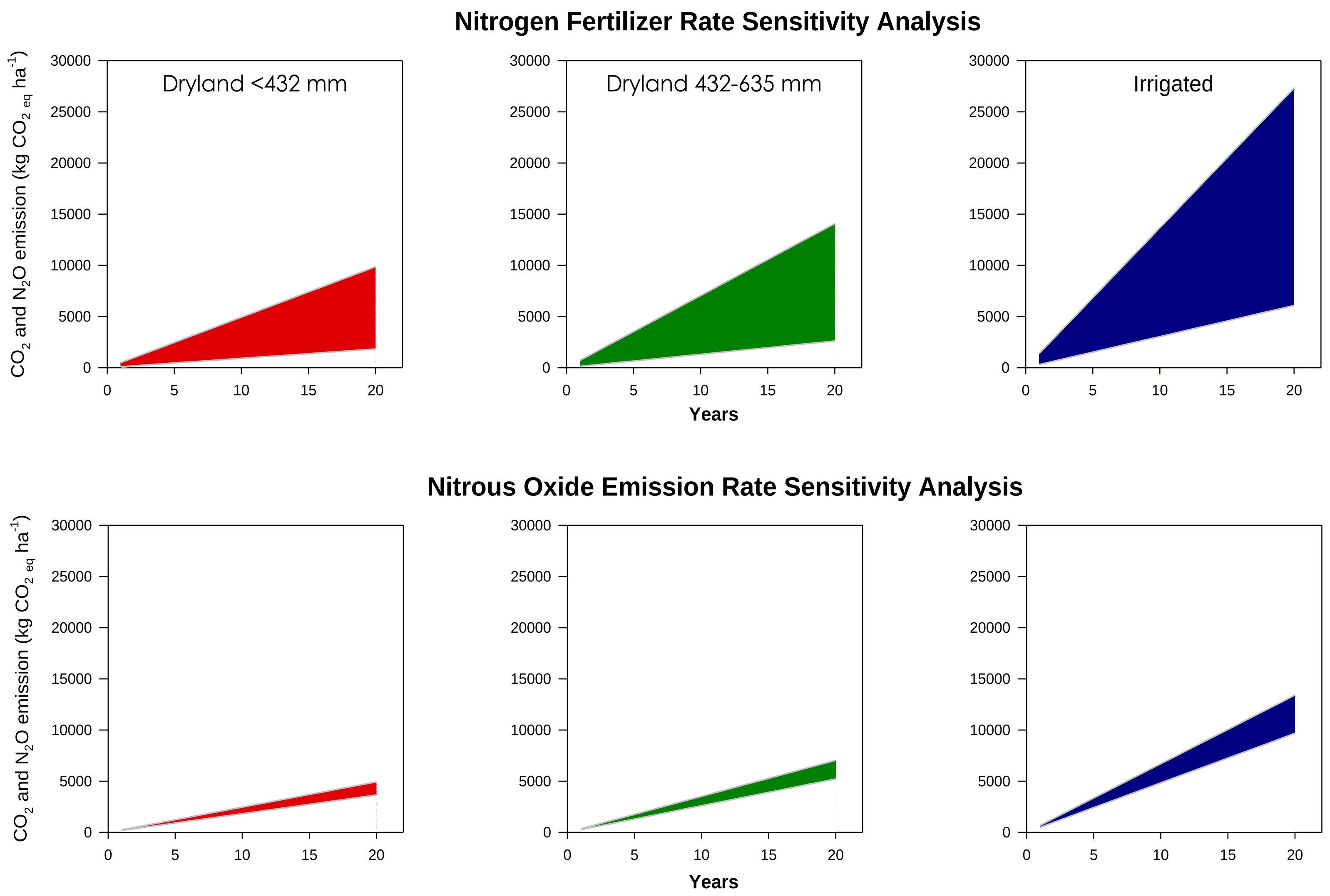


Figure 3: Net CO_2 equivalent balance as a result of canola production CO_2 and N_2O emissions (debit) and biodiesel combustion CO_2 emissions (credit) for three agroecological zones in eastern Washington.

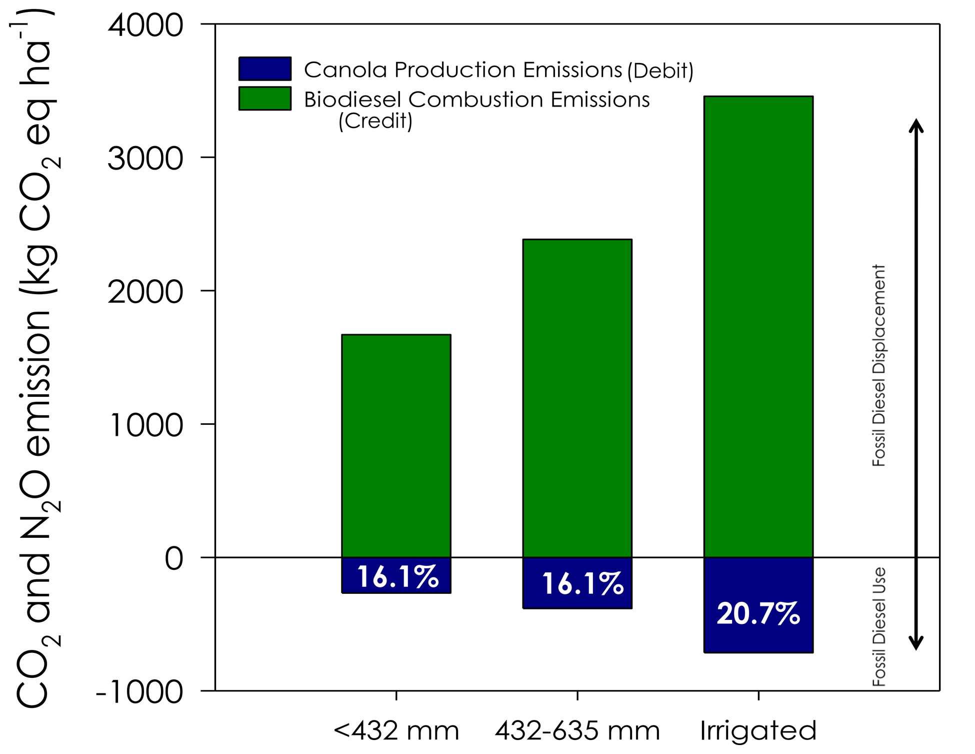
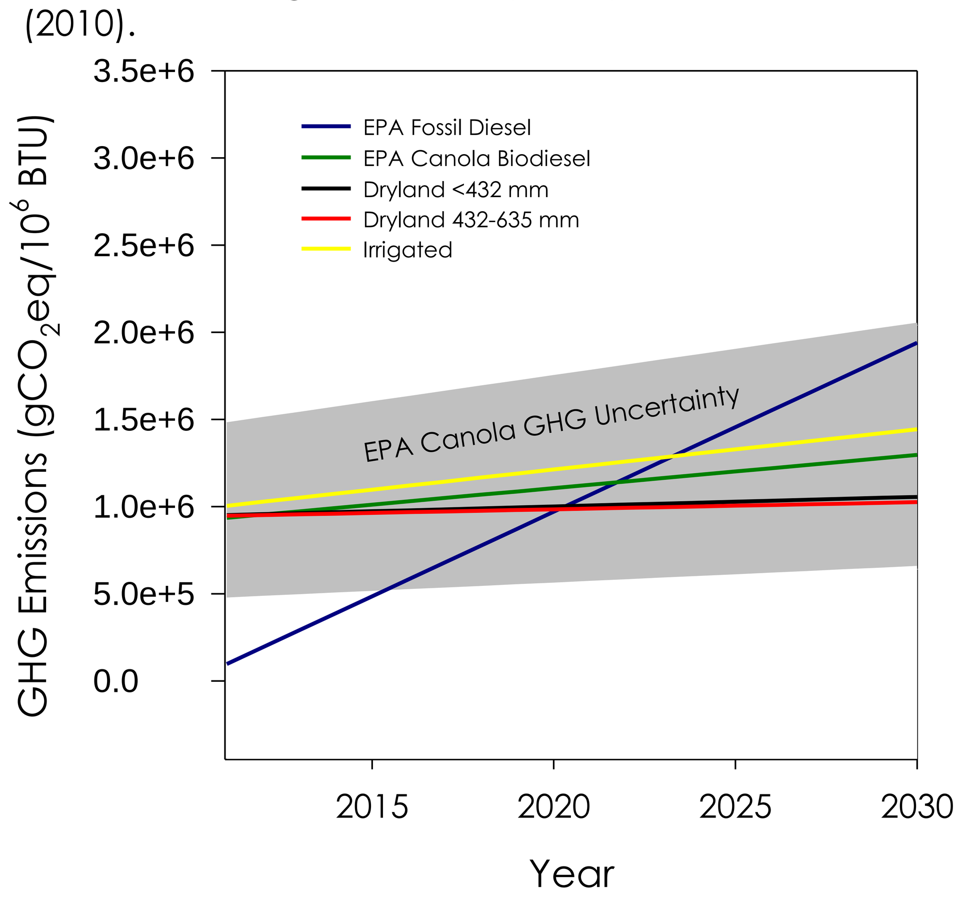


Figure 4: 30-Year cumulative annual greenhouse gas emissions EPA fossil diesel, EPA canola biodiesel, and simulated canola produced in eastern Washington. Partially adapted from EPA (2010).



References

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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	N Fert. Range	-----Agroecological Zone-----		
Parameter		<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 Range	-----Agroecological Zone-----		
Parameter		<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