PROJECT DETAILS

- **Title**: Nitrogen Dynamics
- **Funders:** Agriculture and Agri-Food Canada, Alberta Canola, Canola Council of Canada, Manitoba Canola Growers and SaskCanola
- **Research program:** Growing Forward
- **Principal investigator:** Robert Blackshaw (Agriculture and Agri-Food Canada, Lethbridge)
- **Collaborators/additional investigators:** Xiying Hao, Neil Harker, John O'Donovan, Eric Johnson, Randy Kutcher, Cecil Vera
- **Year completed:** 2013

Executive summary

This study was originally funded by the Alberta Canola Producers Commission and Saskatchewan Canola Development Commission and was subsequently rolled into the Canola Science Cluster to complete it. The field component of this multi-site experiment was previously completed but continuing funds were allocated to complete soil and plant N analyses, conduct statistical analysis of data, perform extension activities, and pay scientific publication costs.

Weed tissue N concentration and weed biomass data confirmed that hybrid cultivars are more competitive with weeds than open-pollinated cultivars. Weed tissue N concentration was often lower with polymer-coated urea (ESN) than with urea, indicating that crop-weed competition for soil N might be reduced if ESN were utilized.

Hybrid canola yielded more than open-pollinated in 75% of the cases. Both hybrid and open-pollinated canola responded positively to higher N fertilizer rates in about 50% of the cases. ESN compared with urea fertilizer increased canola yield in only 25% of the cases. Canola yield was higher with 100% compared with 50% in-crop herbicide rates in 60% of the cases.

Over all sites and years, nitrous oxide emissions averaged 20% less with ESN than with urea, indicating the potential merits of ESN use especially in wet environments. Cumulative nitrous oxide emissions over the three growing seasons were lower (0.15 to 2.97 kg N $year^{-1}$ for all sites) than most other agricultural regions of the world. Indeed, this attribute can be utilized as a marketing advantage when selling canola domestically and on the export market.

Final report

Introduction

Fertilizer and herbicides are two major input costs for most growers. Nitrogen fertilizer costs have more than doubled in recent years thus any increase in N use efficiency will reduce costs and increase farm profits. Previous research has documented that many agricultural weeds successfully capture N fertilizer that otherwise would be used by the crop. Can agronomic systems be developed to reduce N losses to weeds and maximize N utilization by crops?

An increasingly important topic facing Canadian agriculture is the environmental impact of our production systems. Greenhouse gases and global warming are one such issue. Carbon dioxide (CO_2) is the major greenhouse gas but emissions from agriculture are relatively small. However, agriculture is the major source of two other greenhouse gases, namely methane and nitrous oxide (N_2O). Nitrous oxide is over 300 times more potent than CO_2 as a greenhouse gas and thus will come under greater scrutiny in future years. Can agronomic production systems be developed to reduce N_2O emissions from Canadian agriculture? A proactive approach to finding solutions to this potentially contentious issue is desired.

This experiment was initiated in 2005 with funds from the Alberta Canola Producers Commission and the Saskatchewan Canola Development Commission. The field component of this multi-site experiment was completed in 2009 but continuing funds have been allocated through the Canola Cluster to complete soil and plant N analyses, conduct statistical analysis of data, and pay scientific publication fees.

Objectives

1. Determine whether high yielding canola hybrids require greater amounts of N fertilizer compared with open-pollinated cultivars?
2. Determine the potential benefits of polymer-coated urea (slow release) fertilizer in terms of crop yield and/or quality.
3. Determine whether competitive cultivars of canola and/or use of coated urea fertilizer will reduce the amount of N captured by weeds and thus reduce the overall level of weed competition.
4. Determine if reduced amounts of herbicide be used if competitive cultivars and/or slow release N fertilizer is utilized in a multi-year approach.
5. Determine whether nitrous oxide (N_2O) emissions can be reduced by using coated urea fertilizer or growing more productive cultivars that have a greater N demand.

Find more information on this project and many other relevant canola studies on the Canola Research Hub.
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Milestones

2010-11: Complete laboratory analyses of all collected plant and soil samples from all experiments. Conduct statistical analyses of all data over sites and years. Begin writing scientific manuscripts. Prepare annual report.
2011-12: Conduct extension activities at appropriate venues. Continue writing the scientific manuscripts. Prepare annual report.
2012-13: Continue extension activities and complete writing of all scientific manuscripts. Prepare final report.

Outputs

Determine new knowledge on the use of hybrid canola cultivars and polymer-coated urea (ESN) in terms of potential benefits such as improving canola yield and/or quality. Develop improved best management practices for economically profitable and environmentally sustainable canola production in Canada.

Methodology

This study was initiated at three Alberta sites in 2005 (Lethbridge, Lacombe and Beaverlodge) and at two Saskatchewan sites in 2006 (Scott and Melfort). Treatments consisted of two varieties of glufosinate-resistant canola (hybrid InVigor 5020 and OP LBD2393) and two varieties of barley (hulled AC Lacombe and semi-dwarf hulled Vivar), urea or polymer-coated urea (ESN) at rates of 100% or 150% of recommended levels to reach target yields. In-crop herbicides were applied at 50% or 100% of recommended rates. Canola and barley were grown in rotation with both phases of the rotation present each year. Canola was seeded at 150 seeds/m^2 and barley at 300 seeds/m^2 with a 9” row spacing using a zero-till seed drill. Treatments are applied on the same plots in four consecutive years to determine cumulative effects over time.

Data collected included crop and weed emergence dates, crop and weed density, crop and weed nitrogen concentration at 4, 8 and 12 weeks after emergence, weed biomass shortly before harvest, crop maturity date, crop yield, and crop quality parameters such as oil and protein concentration. Nitrous oxide fluxes were determined at two week intervals during the growing season at the three Alberta sites using a vented chamber method with detachable collars. Soil nitrogen was determined at the initiation and conclusion of the study.

Results and Discussion

Weed tissue N concentration and weed biomass were often lower with hybrid compared with open-pollinated (OP) canola (Tables 1 and 2). Additionally, weed tissue N concentration was often lower with ESN than with urea, indicating that crop-weed competition for soil N might be reduced if ESN were utilized (Table 1).

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Hybrid canola yielded more than open-pollinated canola in 75% of the cases (Table 3). Both hybrid and open-pollinated canola responded positively to higher N fertilizer rates in about 50% of the cases (Table 4). ESN (polymer-coated urea) compared with urea fertilizer increased canola yield in 25% of the cases (Table 5). Canola yield was higher with 100% compared with 50% in-crop herbicide rates in 60% of the cases (Table 6). Canola seed oil concentration was similar with ESN and urea in 19 of 20 site-years (data not shown).

Except for a few occasions with higher nitrous oxide emissions from urea than ESN early in the growing season and higher fluxes from ESN than urea later on, nitrous oxide fluxes were often similar among all treatments (see Figure 1 for Lethbridge data from 2006-2008). Nitrous oxide fluxes varied over the growing season and peak fluxes were always associated with high rainfall events. Overall, nitrous oxide emissions across the three experimental sites (Lethbridge, Lacombe, Beaverlodge) averaged 20% less with ESN than with urea, indicating the merits of ESN use especially in wet environments. Cumulative nitrous oxide emissions over the three growing seasons were low (0.15 to 2.97 kg N year^{-1}) for all treatments and sites. These values are much lower than most other agricultural regions of the world and thus this study confirms that nitrous oxide emissions are not a major concern on the Canadian prairies.

Extension of study results has occurred through two scientific papers, four conference proceedings, several Canola Summit and ACPC grower meetings, and one farm press article.

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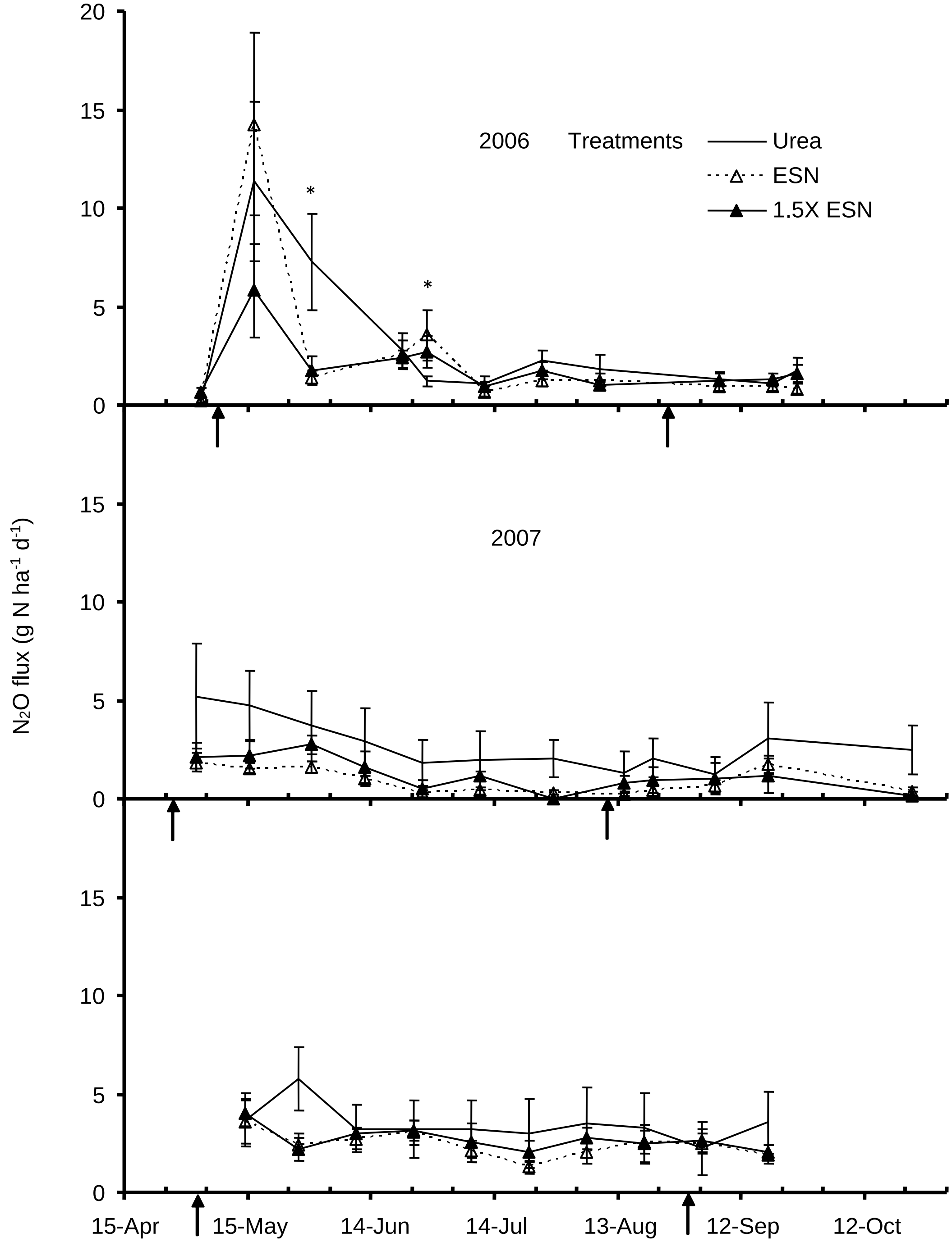

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Figure 1. Nitrous oxide fluxes from canola plots in response to N fertilizer treatments from 2006 through 2008 growing seasons at Lethbridge, AB (arrows indicate planting and harvest dates; * indicates dates with significant fertilizer treatment effects; vertical bars represent standard error of the mean).

Table 1. Wild oat, wild buckwheat, and cleavers N concentration response to cultivar, N fertilizer formulation, and N fertilizer rate determined 4 and 8 weeks after emergence when competing with canola.

	Cultivar		N fertilizer form		N fertilizer rate	
	OP[a]	Hybrid	Urea	ESN	100%	150%
	g/kg					
Wild oat						
Lethbridge						
2005 - 4 wk	53 a	52 a	53 a	53 a	51 b	53 a
2005 - 8 wk	28 a	23 b	27 a	24 b	25 b	28 a
2006 – 4 wk	49 a	48 a	50 a	46 b	48 a	49 a
2006 – 8 wk	34 a	34 a	38 a	27 b	30 b	38 a
2007 – 4 wk	45 a	40 b	45 a	41 b	40 b	46 a
2007 – 8 wk	18 a	15 b	19 a	16 b	15 b	19 a
2008 – 4 wk	51 a	51 a	52 a	51 a	51 a	52 a
2008 – 8 wk	20 a	21 a	23 a	19 b	20 b	23 a
Lacombe[b]						
2005 – 4 wk	54 a	54 a	54 a	53 a	53 a	54 a
2005 – 8 wk	32 a	33 a	34 a	30 b	29 b	35 a
2006 – 4 wk	54 a	50 b	55 a	50 b	53 a	53 a
2006 – 8 wk	37 a	33 b	39 a	31 b	33 b	38 a
2008 – 4 wk	51 a	52 a	53 a	49 b	49 b	53 a
2008 – 8wk	38 a	39 a	41 a	35 b	35 b	41 a
Beaverlodge[c]						
2005 – 4 wk	53 a	52 a	52 a	53 a	50 b	55 a
2005 – 8 wk	19 a	16 b	21 a	16 b	16 b	21 a
2007 – 4 wk	55 a	54 a	55 a	54 a	54 a	55 a
2007 – 8 wk	34 a	31 b	35 a	30 b	30 b	34 a

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Wild buckwheat						
Lethbridge						
2005 – 4 wk	32 a	28 b	29 a	30 a	28 b	33 a
2005 – 8 wk	19 a	18 a	20 a	15 b	15 b	20 a
2006 – 4 wk	45 a	44 a	46 a	41 b	42 b	46 a
2006 – 8 wk	34 a	29 b	38 a	25 b	28 b	36 a
2007 – 4 wk	39 a	34 b	39 a	35 b	34 b	39 a
2007 – 8 wk	27 a	23 b	26 a	24 a	22 b	28 a
2008 – 4 wk	41 a	42 a	42 a	41 a	42 b	51 a
2008 – 8 wk	21 a	20 a	23 a	18 b	19 b	22 a
Lacombe[d]						
2006 – 4 wk	49 a	50 a	50 a	49 a	48 b	51 a
2006 – 8 wk	39 a	40 a	42 a	36 b	37 b	42 a
2008 – 4 wk	48 a	49 a	51 a	46 b	46 b	51 a
2008 - 8 wk	41 a	36 b	42 a	36 b	39 a	40 a
Beaverlodge[e]						
2005 – 4 wk	53 a	53 a	53 a	53 a	51 b	56 a
2005 – 8 wk	29 a	28 a	31 a	27 b	25 b	33 a
Cleavers						
Beaverlodge[f]						
2007 – 4 wk	52 a	52 a	54 a	50 b	50 b	55 a
2007 – 8 wk	38 a	35 b	38 a	35 b	36 a	37 a
2008 – 4 wk	44 a	45 a	45 a	45 a	42 b	47 a
2008 – 8 wk	29 a	30 a	32 a	27 b	28 b	33 a

[a]Means within a weed species, site, year, sampling time and treatment followed by the same letter are not significantly different (*P* > 0.05) according to Fisher's protected LSD.

[b]Flooded conditions due to excessive rainfall prevented data collection at Lacombe in 2007.

[c]Data was not collected at Beaverlodge in 2006 and 2008 due to insufficient wild oat plants in many plots.

[d]Insufficient wild buckwheat plants in many plots in 2005 and semi-flooded conditions due to excessive rainfall in 2007 precluded data collection.

[e]Data was not collected in 2006, 2007 and 2008 in Beaverlodge due to insufficient wild buckwheat plants in many plots.

[f]Sufficient cleavers plants were only present in all plots in the latter two study years at Beaverlodge.

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Table 2. Weed biomass response to cultivar and herbicide rate when competing with canola.

	Cultivar		Herbicide rate	
	OP[a]	Hybrid	50%	100%
	---------------------- kg ha^{-1}		----------------------	
Lethbridge				
2005	747 a	770 a	928 a	589 b
2006	182 a	112 b	282 a	17 b
2007	--[b]		2019 a	248 b
2008	386 a	283 b	481 a	21 b
Lacombe				
2005	12 a	4 b	9 a	7 a
2006	317 a	51 b	257 a	111 b
2007	890 a	697 b	931 a	642 b
2008	1543 a	746 b	2194 a	157 b
Beaverlodge				
2005	135 a	52 b	110 a	24 b
2006	--[b]		162 a	25 b
2007	500 a	293 b	572 a	221 b
2008	28 a	24 a	51 a	4 b
Melfort[c]				
2007	186 a	139 b	128 a	102 a
2008	2221 a	1702 b	2285 a	514 b
2009	522 a	447 a	963 a	104 b
Scott[c]				
2007	619 a	367 b	963 a	22 b
2008	925 a	732 b	1385 a	316 b
2009	3640 a	2933 b	4675 a	1855 b

[a]Means within a site, year and treatment followed by the same letter are not significantly different ($P > 0.05$) according to Fisher's protected LSD.

[b]Weed biomass was lower with hybrid compared with OP canola (1349 vs. 2368 kg ha^{-1} at Lethbridge in 2007; 69 vs. 212 kg ha^{-1} at Beaverlodge in 2006) at the 50% but not at the 100% herbicide rate.

[c]Weed biomass was not collected in the first year of the experiment (2006) at Melfort and Scott.

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Table 3. Mean yield increase of hybrid compared with OP canola when significant (P<0.05) differences occurred (15 of 20 site-years).

	kg/ha	bu/ac
Lethbridge	260	5
Lacombe	670	12
Beaverlodge	430	7
Melfort	290	5
Scott	340	6
Mean	400	7

Table 4. Mean yield increase with 150% compared with 100% N fertilizer when differences occurred (10 of 20 and 13 of 20 site-years for OP and hybrid canola, respectively).

	kg/ha	bu/ac
Lethbridge	280	5
Lacombe	350	6
Beaverlodge	330	6
Melfort	230	4
Scott	225	4
Mean	280	5

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Table 5. Mean yield increase with ESN compared with urea when differences occurred (5 of 20 site-years).

	kg/ha	bu/ac
Lethbridge	230	4
Lacombe	290	5
Beaverlodge	220	4
Melfort[1]	--	--
Scott	160	3
Mean	230	4

[1]Canola yields were similar with ESN and urea at Melfort in all years.

Table 6. Mean yield increase with 100% compared with 50% in-crop herbicide rate when differences occurred (12 of 20 site-years).

	kg/ha	bu/ac
Lethbridge	340	6
Lacombe	660	12
Beaverlodge	170	3
Melfort	230	4
Scott	390	7
Mean	340	6

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