Which Crop Inputs Have the Greatest Impact on Canola Yield?

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INTRODUCTION

Canola production in Western Canada relies heavily on the use of inputs such as pesticides, fertilizer and seed. These three inputs garner the most attention because their costs have risen rapidly over the past decade. Canola prices declined from 2002 to 2007, but have doubled from 2007 to 2010 (Figure 1a). In the same time frame, the Crop Production Input Price Index (seed, fertilizer, pesticides) rose about 30% from 2002 to 2007, and increased about 50% from 2007 to 2010 (Figure 1b). Fertilizer prices have steadily risen with a 3-fold increase in the fertilizer price index from 2002-2010 (Figure 1b). When this study was initiated, farmers were questioning whether they could reduce these inputs without incurring yield losses that exceed cost savings.

A multi-year study was conducted at six locations on the Canadian Prairies to examine the role of inputs in canola cropping systems. Since it was unreasonable to look at all possible input combinations, the experiment was designed to determine if inputs had the same impact in a system that targeted high yield as in an input package that targeted low yield [the full and empty input concept]. The experiment involved a canola (*Brassica napus* L.) – barley (*Hordeum vulgare* L.) crop sequence, therefore the studies were able to examine if inputs would have cumulative effects over time. Results from only the canola phase of the crop sequence will be presented.

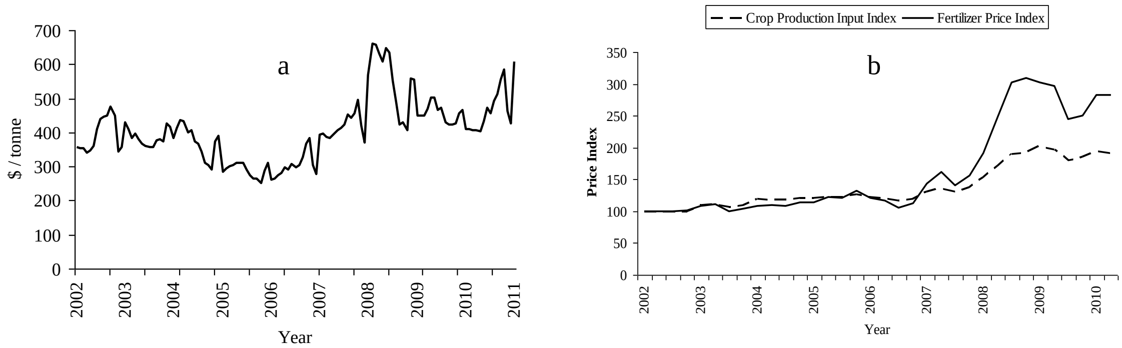

Figure 1. a) Western Canadian canola seed prices 2002-2011 (Source: Canola Council of Canada 2011); b) Western Canadian crop production input index and fertilizer price index 2002-2010. Price index is based on a value of 100 for 2002 (Source: Statistics Canada 2011).

MATERIALS AND METHODS

Studies were designed as a split-plot factorial with canola and barley as main plots and inputs in sub-plots. The same input strategy was applied to each plot for 4 years to evaluate cumulative effects in a canola-barley or barley-canola sequence. Wild oat (*Avena fatua* L.) and wild buckwheat (*Polygonum convolvulus* L.) were seeded at 100 seeds m^{-2} into all plots, in year one only. Crops were direct-seeded and treatments are described in Table 1.

The full canola input package consisted of hybrid canola sown at 150 seeds m^{-2} (7.1 kg ha^{-1}), fertilized so that available soil plus fertilizer N, P, K, S were sufficient for target yields of 1700 to 2500 kg ha^{-1} depending on location. The full herbicide rate was 500 and 15 g ai ha^{-1} of a tank-mix of glufosinate and clethodim, respectively. The empty canola package consisted of open pollinated canola sown at 75 seeds m^{-2} (3.6 kg ha^{-1}), no fertilizer, and no herbicide. The 50% fertilizer rate targeted 50% yields, while the 50% herbicide rate was 250 and 7.5 g ai ha^{-1} of glufosinate and clethodim, respectively. Studies were initiated in 2005 at Lacombe, Beaverlodge and Fort Vermilion in AB, and Scott and Melfort SK, and in 2006 at Lethbridge AB. Data collection included plant density, weed density and biomass, residual soil nutrients, grain yield, and crop quality factors.

Table 1. Input treatment descriptions.

1) Full package (Full)	2) Empty package (Empty)
3) Full package minus genetics (F_m_G)	4) Empty package plus genetics (E_p_G)
5) Full package minus seed (F_m_S)	6) Empty package plus seed (E_p_S)
7) Full package minus 50% fertilizer (F_m_50F)	8) Empty package plus 50% fertilizer (E_p_50F)
9) Full package minus 100% fertilizer (F_m_F)	10) Empty package plus 100% fertilizer (E_p_F)
11) Full package minus 50% herbicide (F_m_50H)	12) Empty package plus 50% herbicide (E_p_50H)
13) Full package minus 100% herbicide (F_m_H)	14) Empty package plus 100% herbicide (E_p_H)

*G=hybrid cultivar; S=high seeding rate.

RESULTS AND DISCUSSION

When combined across site-years, removing all fertilizer from the full input package resulted in slightly higher canola plant densities (Table 2). This indicates that fertilizer was causing seedling damage in some instances, even though fertilizer was either side or mid-row banded. Treatments seeded at 75 seeds m^{-2} had significantly lower plant densities than treatments seeded at 150 seeds m^{-2}. Adding inputs other than seed to an empty input package did not increase plant density.

Removing herbicide from a full input package resulted in significantly higher weed densities and weed biomass (Table 2); however, cutting herbicide rates by 50% resulted in no statistical difference. The addition of either 50 or 100% herbicide to an empty input package were the only inputs that reduced weed density or weed biomass in an empty input package.

Table 2. Effect of crop inputs on canola plant density, weed density, weed biomass and canola yield. Mean of 21 site-years.

Effect / Contrast	Plants (# m^{-2})	a	b	Weed Density (# m^{-2})	a	b	Weed Biomass (kg ha^{-1})	a	b	Canola Yield (kg ha^{-1})	a	b
Full	99		**	39		**	[d]			2469		**
F_m_50H	101		**	51		**	24	*	**	2442		**
F_m_50S	65	**		43		**	11		**	2395		**
F_m_50F	106		**	44		**	9		**	2205	*	**
Full_m_G	91	*	**	36		**	10		**	2125	**	**
Full_m_F	111	**	**	39		**	12		**	1807	**	**
Full_m_H	96		**	157	**		1164	**		1484	**	**
E_p_H	65	**		54		**	50	**	**	1468	**	**
E_p_50H	60	**		92	**	**	219	**	**	1283	**	**
E_p_F	54	**		211	**		2465	**		899	**	
E_p_G	67	**		178	**		1621	**		878	**	
E_p_50F	56	**		199	**		2351	**		834	**	
E_p_S	95		**	164	**		1701	**		792	**	
Empty	60	**		199	**		2041	**		701	**	

[a] Statistical significance ('*' = 0.05 ≥ P value ≥ 0.01; and '**' = P value < 0.01) of comparisons to 'Full' treatment.

[b] Statistical significance ('*' = 0.05 ≥ P value ≥ 0.01; and '**' = P value < 0.01) of comparisons to 'Empty' treatment.

[c] 'Full' treatment was not included for the analysis of weed biomass.

Removing 50% and 100% fertilizer, genetics, and 100% herbicide from a full input package resulted in lower canola yields (Table 2). The impact of cutting fertilizer by 50% was cumulative since canola yields were not lower than the full input package in the first year of the study, but were significantly lower in Years 2, 3, and 4 (Table 3). Eliminating herbicide resulted in no detectable yield reduction in Year 1; however, it resulted in severe yield reductions in Years 2, 3, and 4 (Table 3). This indicates that it may be able to cut and eliminate inputs for a short time period; however, reduction or elimination will severely limit yield potential over time. The only inputs that improved yields of the empty input package was 50 and 100% herbicide when data were combined over all years (Table 2); however, adding genetics and full rates of fertilizer resulted in higher yields in the first two years of the study (Table 3). This indicates that these two inputs were not able to overcome the cumulative effects of weed interference over the four years of the study.

Yield responses in Table 2 from the addition of seed, genetics, fertilizer and herbicide were 91, 177, 198, and 768 kg ha^{-1}, respectively. The expected total yield response from these inputs is 1234 kg ha^{-1}; however, the difference in yield between the full and empty input package was 1768 kg ha^{-1}. This indicates that there may be synergistic yield interactions when inputs are stacked. Examining the year 4 data in Table 4 provides an indication of the cumulative effects of inputs over time. Yield responses from the addition of seed, genetics, fertilizer and herbicide were 6, 56, 138, and 1125 kg ha^{-1}, respectively; however the difference in yield between the empty and full input package was 2532 kg ha^{-1}.

Table 3. Effect of adding and removing inputs on canola yield over time. P values are for making pair-wise comparisons of treatments where inputs were removed with the full input package and for making pair-wise comparisons of treatments where inputs were added with the empty input package.

	Yield (kg ha^{-1})				P value for contrasts vs Full by Time			
Treatment	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4
1 Full	2835	2436	1958	2641				
2 Full_m_G	2599	1951	1881	2084	0.091	0.003	0.004	0.040
3 F_m_50S	2974	1943	2072	2539	0.863	0.560	0.429	0.497
4 F_m_50F	2752	2208	1755	2077	0.686	0.039	0.002	0.006
5 Full_m_F	2387	1659	1438	1712	0.001	0.000	0.000	0.000
6 F_m_50H	2035	1143	1088	749	0.390	0.899	0.353	0.212
7 Full_m_H	2696	1754	724	633	0.314	0.000	0.000	0.000
					P value for contrasts vs Empty by Time			
8 Empty	1512	801	286	110				
9 E_p_G	1739	1055	470	166	0.061	0.028	0.172	0.615
10 E_p_S	1638	959	356	116	0.295	0.213	0.432	0.762
11 E_p_50F	1639	1010	329	254	0.300	0.153	0.259	0.524
12 E_p_F	1880	1053	314	247	0.019	0.016	0.263	0.950
13 E_p_50H	2035	1143	1088	749	0.001	0.000	0.000	0.000
14 E_p_H	2042	1339	1243	1234	0.000	0.000	0.000	0.000

CONCLUSIONS

When data were combined across all site-years, the ranking of the effect of inputs on canola yield was herbicide > fertilizer = genetics > seed. In the final year of the study where cumulative effects were observed, the ranking was herbicide > fertilizer > genetics > seed. From this study, there is some indication that inputs can be reduced or eliminated for a short time, however yield penalties can be high if repeated over time. Inputs appear to interact to provide yield benefits higher than the sum of the individual yield responses.

ACKNOWLEDGEMENTS

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