

How to Make \$300 Per Acre With Canola at \$5 Per Bushel: the Challenge of Integrating Research into Cropping Systems

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Introduction

As farmers continue to struggle with tight margins for production of field crops, many farmers are carefully re-evaluating the net economic value of crop inputs and management practices. The traditional approach used by agronomic scientists, extension specialists and industry marketers for this type of evaluation is to examine the expected increase in revenues and expenses for each input, individually. Unfortunately, this sort of “marginal returns analysis” does not describe the optimum overall profitability for the input within the overall cropping system package. The limitations of using agronomic and economic information developed from research into single inputs are illustrated in the following discussion.

Theoretical Limitations of Using Data from Research on Single Inputs

Marginal returns analysis is typically used to describe the optimum rate of applying a single input such as nitrogen fertilizer. This approach seems to be relatively simple and rational, if viewed in isolation from the rest of the cropping system. The first step in this type of economic analysis is to gather information on the expected yield response to the selected input. This sort of information is usually generated from experiments in which all factors other than the factor in question are optimum.

In the hypothetical example in Figure 1, the maximum biological yield and gross revenue for canola occurs at 110 lb of N per acre when all other factors (e.g., other nutrients, weed control, etc.) are not limiting. To calculate the maximum economic yield, we must incorporate the crop price and fertilizer cost into our analysis. The maximum economic yield occurs where the spread between revenue and costs is greatest. This optimum yield can be determined quantitatively by comparing the additional revenue (marginal revenue) and additional costs (marginal costs) for each increment in N fertilizer. We assume that farmers should continue to add additional increments of fertilizer as long as that next increment will result in more marginal revenue than marginal cost. The economic optimum occurs at a point on the response curve where marginal revenue equal marginal costs. Any additional increments of fertilizer will not produce a profit. In the example listed below, the economic optimum rate of fertilizer N is 90 lb N per acre.

Unfortunately, this approach of carefully evaluating the increased revenue and costs of a single input is overly simplistic and creates unrealistic expectations of how to achieve profitable crop yields with high levels of investment in crop inputs. The misuse of yield responses to single inputs occurs when the individual economic responses are assumed to be meaningful for a farmer’s field, where other potentially limiting inputs (e.g., for crop protection) must be incorporated at significant cost into an integrated crop production system.

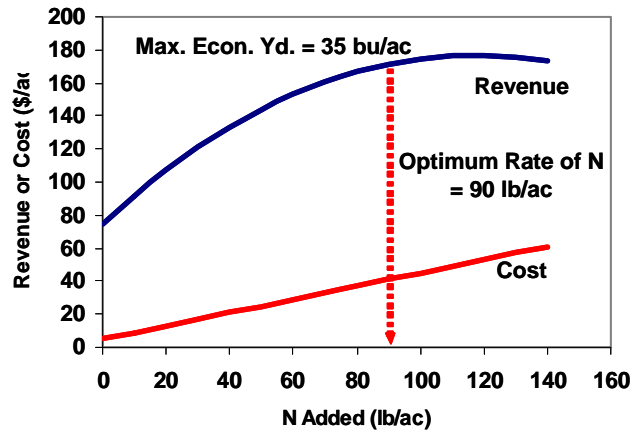


Figure 1. Effect of N fertilizer on canola revenue and costs (assuming a canola price of \$5/bu and fertilizer N at \$0.40/lb at the farm gate).

For example, as illustrated in Table 1, we might use the results of marginal returns analysis for a single input (such as N fertilizer) to start putting together the economic expectations for a farmer’s crop production system.

Table 1. Hypothetical yield increases and economic returns for nitrogen fertilization of canola at \$5 per bushel

Input or Treatment	Yield Increase (bu/ac)	Increase in Gross Revenue (\$/ac)	Operating Cost (\$/ac)	Gross Margin (\$/ac)
Check or Base Yield*	15	\$75.00	\$55.00	\$20.00
N (90)	20	\$100.00	\$30.00	\$60.00

* Noncertified seed, mach. operating & repair, no fertilizer, no pesticide

However, if we incorporate all of the crop inputs into the farmer’s system in the same manner, without discounting the net value of those inputs for their interdependence, we arrive at a totally unrealistic theoretical estimate of yield and profit (Table 2). Ironically, in this rather exaggerated case, the realistic gross margin after purchasing all the inputs listed is less than for the “check” where the only crop input was a plain source of seed.

Most agronomists and farmers know by intuition that responses to individual responses cannot be simply added together in an “end-to-end” fashion. Yet, it is difficult to explain exactly how a series of apparent truths about responses to individual inputs is transformed into a “fairy-tale” when the responses are added together into a cropping system. This contradiction is created when we take any individual input’s yield response at face value, without accounting for the fact that this sort of information is typically gathered under conditions where all inputs except the input in question are “looked after” (to ensure they are not limiting yield) but not accounted for in terms of their cost to enable the response to the input in question (e.g., N fertilizer). In other words, although the input costs are independent and add up in linear manner, input responses are biologically and economically interdependent and, therefore, do not add up linearly. Hence, the results of single input studies cannot be applied directly to whole cropping systems.

Table 2. Hypothetical yield increases and economic returns for production of canola at \$5 per bushel

Yield Source or Response	Yield (bu/ac)	Revenue (\$/ac)	Cost (\$/ac)	Margin (\$/ac)
Check or Base Yield*	15	\$75.00	\$50.00	\$25.00
N (90)	20	\$100.00	\$40.00	\$60.00
P (30)	5	\$25.00	\$9.00	\$16.00
K (30)	4	\$20.00	\$7.50	\$12.50
S (25)	6	\$30.00	\$7.50	\$22.50
B (1)	2	\$10.00	\$7.50	\$2.50
Zn (5)	3	\$15.00	\$12.50	\$2.50
Insecticide	15	\$75.00	\$15.00	\$60.00
Herbicide	15	\$75.00	\$25.00	\$50.00
Fungicide	10	\$50.00	\$25.00	\$25.00
Treated Hybrid Seed	10	\$50.00	\$25.00	\$25.00
Theoretical Yield	105	\$525.00	\$224.00	\$301.00
Realistic Yield	35	\$157.50	\$224.00	-\$66.50

* Noncertified seed, mach. operating & repair, no fertilizer, no pesticide

As a result, most agronomic research data concerning a single input overestimates the net value of that input within a whole cropping system, especially if a large number of inputs are required to create that response (e.g., to create opportunities for large N responses in canola). Therefore, the true economic value of inputs to farmers is often much lower than perceived by scientists, agronomists and marketers. This difference in perceived value explains why many farmers are often justifiably cautious about investing in new technology.

Overestimation of crop input value has led to underestimation of other crop management tools such as crop varieties with genetic resistance to pests, native fertility of soil, crop rotation for pest control, etc. Therefore, agronomists and farmers must be challenged to move from input-based cropping systems to knowledge-based systems. Farmers and agronomists have historical experience, field scouting skills and other assets that are very valuable and which should be used to move away from input-based “recipes” to selective and adaptable practices. In a sense perhaps, we need to move “back to the future,” from the concept of “crop production” to “field husbandry” where the benefits of a long term and intimate relationship with each field are recognized and used to advantage.

Yield Responses from Research with Single vs. Multiple Inputs: A Case Study

To learn more about how to translate typical research trials into real life cropping systems, we examined the individual and combined effects of various levels of fertilization, crop protection and genetic yield potential on canola yield, quality and profitability. This three-year research project was supported by canola producers in Manitoba and Saskatchewan, plus Manitoba Agriculture’s Covering New Ground

Program, the Potash and Phosphate Institute and the Canada-Manitoba Agri-food Research and Development Initiative.

As shown in Table 3, the rate of return to low, medium and high input cropping systems varied substantially with growing conditions. At the Brandon Research Centre in 2001, yield potential was excellent and intensive application of crop inputs resulted in a yield increase of 40 bushels per acre and a substantial improvement in economic margin. For 2002 and 2003, where yields were limited by adverse growing conditions, the agronomic response was modest and economic response was generally negative.

The difference between the yield and economic responses for individual crop inputs and the overall response to those inputs as part of a whole cropping system was substantial (Table 4). The individual yield responses to improved genetics, aggressive fertilization, and application of a complete set of herbicides, insecticides and fungicides were large. Each of the individual inputs appeared to increase in profitability; the responses to variety and fertilizer seemed especially profitable. However, when all the inputs were applied together, the overall yield was significantly less than what might have been expected from adding together the individual yield responses. And, of greater concern, the difference between the theoretical and actual margins for the high input cropping system was very large, resulting in little improvement to the profit margin, compared to the low input system.

Table 3. Yield and economic returns from low, medium, and high crop input packages for canola production at Brandon in 2001, 2002 and 2003 (canola priced @ \$7/bu)

Year		Yield (bu/ac)	Revenue (\$/ac)	Cost (\$/ac)	Margin (\$/ac)	Environmental Factors Affecting Grain Yield and Economics
2001	Low Inputs	6.1	\$42	\$75	-\$33	Good growing season conditions
	Medium Inputs	25.5	\$178	\$191	-\$13	
	High Inputs	46.5	\$326	\$269	\$57	
2002	Low Inputs	0.2	\$1	\$75	-\$74	Very dry conditions in spring. Germination was poor and weed pressure extremely high
	Medium Inputs	6.7	\$47	\$161	-\$115	
	High Inputs	24.3	\$170	\$247	-\$77	
2003	Low Inputs	6.6	\$46	\$75	-\$29	Good growing conditions in May and June, followed by hot, dry weather in July and August that reduced yields
	Medium Inputs	18.6	\$111	\$170	-\$60	
	High Inputs	23.4	\$164	\$236	-\$73	
Average for All Years	Low Inputs	4.3	\$30	\$75	-\$45	
	Medium Inputs	16.9	\$112	\$174	-\$62	
	High Inputs	31.4	\$220	\$251	-\$31	

Table 4: Average benefit of canola crop inputs when yield responses to those inputs are added individually or as a part of a complete cropping system at Brandon in 2001, 2002 and 2003 (canola priced at \$7/bu)

Yield Source or Response	Yield (bu/ac)	Revenue (\$/ac)	Cost* (\$/ac)	Margin (\$/ac)
Base Yield (med. genetics, no fertilizer or pesticide)	4.3	\$30	\$75	-\$45
Variety Response (with all other inputs at high levels)**	4.9	\$34	\$0	\$35
Pesticide Response (with all other inputs at high levels)	14.3	\$100	\$95	\$5
Fertilizer Response (with all other inputs at high levels)	18.8	\$132	\$74	\$58
“Theoretical” Yield If All Inputs Were Additive***	42.3	\$296	\$245	\$52
“Real” Measured Yield With All Inputs at High Levels	31.4	\$220	\$251	-\$31

* Costs for base yield include preseeding glyphosate, seed, machinery, fuel, repairs and other basic costs

** The higher expense for the high yielding canola variety was offset by planting at a lower seeding rate than for the medium yielding variety and using less seed treatment.

*** The benefit of the lower seed treatment costs for the high yielding canola variety is included twice in the theoretical addition of input costs, underestimating those total input costs, compared to reality.

Options for Developing an Integrated Approach to Crop Production Systems

What then is the correct method of translating our knowledge of single input responses into the reality of a whole cropping system? Research data from experiments with single inputs are an important starting point for information, but the true value of an input cannot be determined until it is integrated into an agronomic and economic plan for the whole crop. Some suggestions that may help agronomists and producers to integrate their crop production systems include:

Consider different roles for different groups of crop inputs - One way of looking at a crop is to consider it as an elaborate, complex biological “machine.” Each type of crop input plays a different role in the operation of the machine, but those roles might be classified into four general types. First, there are the “essentials” such as the basic seed, fuel, taxes, etc. that must be paid for in order to produce any crop at all. Second, there are “enhancements” such as fertilizer and superior genetics that increase the performance or yield potential of the crop production system. Third, there are crop protection products that play the role of “repairs” in the crop production system. Contrary to popular perception, pesticides do not add yield or income to a crop production system; they only help to temporarily fix a problem, at best allowing the crop to reach the original yield potential. And, if these “repairs” become too costly for a crop production system, perhaps that is signal to trade that system in on a new system. Fourth, there is group of inputs that serves the role of “maintenance.” These inputs include fertilizers added to a fertile soil to balance crop removal, investment in soil-conserving tillage equipment and inputs, etc..

Increase the apparent cost of an input to account for the cost of other “corequisite” inputs - The expected costs for an individual input should be considered in relation to the number of other inputs that are required to realize a yield increase from the input in question. For example, a farmer cannot expect a substantial response to N fertilizer unless P, K, and S fertility is also accounted for. And, if P, K, and S fertilizer is required, perhaps the revenue and cost curve in Figure 1 should be modified to account for the cost of N, P, K, and S fertilizer, instead of N, alone, as shown in Figure 2

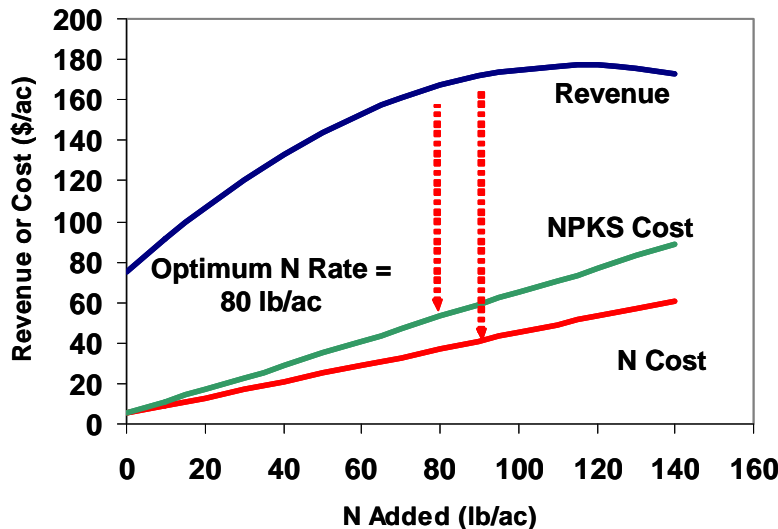


Figure 2. Effect of N, P, K, and S fertilizer on canola revenue and costs

Decrease the apparent returns for an input to account for contributions from other “corequisite” inputs - The expected returns for an individual input should also be considered in relation to the number of other inputs that are required to realize a yield increase from the input in question. For example, each of the inputs listed in Table 2 may contribute positively to the overall yield of the crop. However, if the overall yield increase from all the inputs used together is 20 bu/ac more than the check, instead of the 90 bu/ac expected from the sum of each individual yield increase, then perhaps each expected yield increase should be multiplied or prorated by a factor of 20/90 to account for the difference between the cumulative and the individual effect.

Budget costs and returns for complete cropping systems built on low, medium and high input production systems - Ideally, farmers and agronomists should prepare budgets for entire crop production systems, based on low, medium and high levels of inputs (e.g., for 25 bu/ac, 35 bu/ac, and 45 bu/ac). Such budgets should be realistic for local growing conditions and should be complete, accounting for all inputs that are required to achieve the selected yield goal. Most important, the budgets should be coherent and compatible, with genetic potential, fertility management and crop protection in tune with each other and the overall yield goal.

Summary

Whenever agronomists provide yield response information that is based on research on the effect of a single input, they are promoting the notion that each input's yield response can be added at face value, "end-to-end" with all other input yield responses, into the farmer's cropping system. In other words, we are implying that farmers can make \$300 per acre from growing canola at \$5 per bushel as noted in the previous case study. However, as many farmers already know, the expected yield benefits and economic profits generated by typical research trials do not add up this way; therefore, the benefits and costs for the whole management system should be considered as a package. So, although everyone in agriculture must, by necessity, frequently use information from single input experiments, all of us should keep the following observations in mind:

- although input costs are independent and additive, input responses are biologically and economically interdependent and non-additive
- farmers and agronomists should use their knowledge and experience to develop crop plans that are realistic, compatible and complete for low, medium and high input systems
- farmers, agronomists and scientists should support and conduct experiments with different types of cropping systems so that we can further expand our knowledge and experience