RISK EFFICIENCY OF ALTERNATE CANOLA MANAGEMENT

DECISIONS

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ABSTRACT

This study evaluates profitability and risk associated with eighteen different management decisions for canola production in Alberta. Expected payoff from cultivar selection outweighs the payoff from time of seeding and from time of weed control. Expected payoff was higher from hybrid compared to inbred cultivars. Early spring seeding was more profitable than fall or mid-May seeding. A typical decision in the sample showed positive and significant upper limit risk-expected return tradeoffs. The generalized stochastic dominance analysis revealed that early spring seeding was dominant over fall and mid-May seeding across all risk averse and risk neutral farmers. Weed control at the six-leaf stage was risk efficient for a risk averter. A risk neutral farmer preferred weed control at the three to four-leaf stage or six-leaf stage, depending on cultivar.

INTRODUCTION

Maximizing net revenue and minimizing risks are two major concerns of canola (*Brassica napus* L.*, Brassica rapa* L.) farmers. Production decisions are risky because of the associated stochastic nature of yields. Some risky decisions facing canola producers include cultivar selection, time of seeding, and time of weed control. Recent introductions of hybrid cultivars, herbicide tolerant cultivars, and polymer seed coating have altered production relationships and the profitability and risks associated with these management decisions.

Agronomic studies have documented the yield potential of canola under different management conditions. Alternative seeding dates, fall (late seeding to germinate the

following spring) or early spring, compared to mid-May could be a major economic benefit to prairie producers. (Clayton et al 2004; Karamanos, Harapiak, Flore 2001). Early growth allows canola to better utilize moisture from the spring snowmelt and avoid environmental heat stress at flowering (Degenhardt and Kondra 1981; Johnson et al 1995; Kirkland and Johnson 2000; Kondra 1977). Fall-seeded canola had 22% higher mean yield, but the yield was 81% lower than spring seeded one in four years (Kirkland and Johnson 2000). The lower yield was attributed to inadequate control of winter annual weeds. If weed control was the limiting factor, the recent introduction of herbicide tolerant canola reopens the opportunity for fall seeding.

Several alternative cultivars are available for canola production in the prairies (Angadi et al 2000). The *napus* species is dominant to *rapa* because of a higher yield potential. Cultivars of the *napus* species are further classified into hybrid and inbred. Yield response for hybrids and inbreds might vary over time and space, but Harker et al (2001) have reported higher average yield from hybrid over inbred cultivars in Alberta.

The recent introduction of herbicide tolerant cultivars may provide alternative weed control options. Herbicide application timing and efficacy usually influences the outcome of canola-weed competition much more than the inherent competitiveness of the cultivar (Zand and Beckie 2002). A study in Manitoba found delaying weed control beyond the three to four-leaf stage (the six-leaf stage for early seeded canola) could result into yield loss exceeding 10 percent (Martin, Friesen and Van Acker 2001).

The optimal management decision for a farmer depends on the distribution of net revenues and their utility function. Studies in agricultural economics have used stochastic dominance techniques for isolating efficient decisions from a set of risk inefficient

decisions, due to the difficulty in measuring utility functions and making inferences for a group of farmers (Hardeker, Huirne and Anderson 1997). Stochastic dominance is consistent with the expected utility theory, and does not require the underlying distribution of returns to be normal. Stochastic dominance is also more flexible compared to EV and MOTAD analysis, which reduces the choices to a single optimal plan.

Stochastic dominance analysis involves pair-wise comparisons of decisions based on correspondingly generated streams of returns and associated risks. The distribution function contains information on risk-return trade-offs. But, they fail to provide statistical significance of risk return trade-offs. Stochastic dominance literature usually supplements the analysis with statistical significance of expected returns using parametric or non-parametric techniques. However, more appropriate information would be the statistical significance of risk-return tradeoffs in the sample of decisions.

Despite abundant agronomic studies on yield potential of canola under different management conditions, profitability and risk analysis are still lacking. The objectives of this study are: 1) to analyse the profitability associated with canola management decisions, 2) to estimate upper limit risk-expected return tradeoffs across selected decisions, and 3) to isolate risk efficient decisions from risk inefficient decisions using stochastic dominance analysis.

METHODS

Net Revenue

Net revenues were calculated for each field observation as the total net returns to land and labour. This is appropriate given the differences in land and labour costs across farms (Yiridoe et al 2000). Net revenue in this study was the difference between gross

revenue obtained from selling canola in the market and the associated costs of production. A five-year average annual market price (1996-2000) for canola was used for the gross revenue calculation. Cost of production varied across decisions corresponding to the actual level of inputs applied in the field experiment. Costs included machinery, seed, seed treatment and coating, technology use agreement fees, fertilizers, and pesticides. An additional opportunity cost for fall applied inputs at the rate of 5% per annum was charged to make fall and spring costs comparable.

Stochastic Simulation

Net revenue variability from 18 management decisions obtained from field experiments were used to generate an empirical distribution of 500 site years of net revenues. The field experiment had two cultivars, three seeding dates, and three weed control times (Clayton et al. 2004). An empirical distribution was chosen because it avoids forcing a specific parametric distribution on net revenues. The simulation method proposed by Richardson, Klose and Gray (2000) was followed because it preserves historical relative variability and intra site-year correlations in the simulations. The random component of a management decision was estimated as:

$$\hat{e}_{it} = X_{it} - \hat{X}_{it} \tag{1}$$

Where $\hat{e}_{it}$ refers to the estimated random component of net revenue from the experiment with the ith management decision in the tth site-year. Similarly, X_{it} and $\hat{X}_{it}$ refer to the observed and estimated non-random net revenues, respectively, for the same experiment. Due to limited degrees of freedom in these data, the average of the net

revenues across site-years was used to estimate the non-random component of a management decision.

Following Richardson, Klose and Gray (2000), the inter-management decision correlations (ρ) were estimated for i^{th} and j^{th} decisions as follows:

$$\rho_{ij} = \begin{bmatrix} \rho(\hat{e}_{it}, \hat{e}_{it}) & \rho(\hat{e}_{it}, \hat{e}_{jt}) \\ \rho(\hat{e}_{jt}, \hat{e}_{it}) & \rho(\hat{e}_{jt}, \hat{e}_{jt}) \end{bmatrix} \tag{2}$$

These correlations were preserved on simulated distributions of net revenues for risk efficiency analysis. Ignoring the correlations will bias the variance of the simulated net revenues (Law and Kelton 1991; Richardson, Klose, and Gray 2000; Taylor 1990).

Upper Limit Risk-Expected Return Trade-off

In an uncertain economy where the farmer's utility function is not known, risk exposure due to a decision may also be evaluated under a safety-first framework (Van Kooten, Young and Krautkraemer 1997). A farmer's risk exposure under a safety-first framework (Roy 1952) can be estimated as:

$$Risk = Pr\ (NR < NR^t) \tag{3}$$

Where NR^t refers to a threshold level of simulated net revenue (NR) and Pr is the probability. For a group of farmers, risk exposure may vary due to variation in NR^t corresponding to their annual cash flow commitments. Therefore, an upper limit risk difference (URD) could be relevant to evaluate risk-expected return tradeoffs. Mathematically the URD for a pair of decisions i and j can be defined as:

$$URD_{ij} = maximum\ |Pr\ (NR_i < NR^t) - Pr\ (NR_j < NR^t)| \tag{4}$$

It should be noted the URD identifies risk return trade-off in the sample, it is not used to choose among decisions.

Observations generated as the difference between a series of decisions and a base decision are correlated. Therefore, observations were grouped based on base decisions. Let $\widetilde{MD}$ and $\widetilde{URD}$ be the group wise mean difference and upper limit risk difference due to stochastic yield associated with decisions i and j. The $\widetilde{MD}$ and $\widetilde{URD}$ are not perfectly correlated. This imperfect trade-off is modeled as,

$$(\widetilde{URD} - \mu_U) = \beta(\widetilde{MD} - \mu_M) + \widetilde{\varepsilon} \tag{5}$$

Where $\beta = \text{cov}(\widetilde{URD}, \widetilde{MD}) / \text{var}(\widetilde{MD})$, $E\widetilde{\varepsilon} = 0$, $E(\widetilde{URD}) = \mu_U$, $E(\widetilde{MD}) = \mu_M$ and $\widetilde{\varepsilon}$ is independent of $\widetilde{MD}$. The parameter β is the trade-off, which is also interpreted as marginal upper limit risk response to a change in mean net revenue for a typical pair of decisions. A regular t-test would provide the statistical significance of the parameter estimate.

Risk Efficiency Analysis

Risk efficient decisions were isolated using stochastic dominance techniques for a range of risk attitudes (Meyer 1977). Stochastic dominance involves comparison of cumulative probability distributions of simulated net revenues for each management decision. There are several stochastic dominance criteria (Hardaker, Hurine and Anderson 1997). This study uses generalized stochastic dominance (GSD), which is also called stochastic dominance with respect to a function (Meyer 1977). The GSD is more discriminatory compared to first (FSD) and second (SSD) degree stochastic dominance criteria. Discrimination among decisions is possible with GSD because choices can be ordered based on risks by introducing bounds on absolute risk aversion coefficients (ARAC) within SSD. The ARAC is defined as the negative of the ratio of the second and first derivative of the monotonically increasing Von Neumann-Morgenstern utility

function (Arrow 1971; Pratt 1964). The ARAC can be interpreted as the percentage change in marginal utility per unit change in net revenue. The change may be positive, zero or negative based on risk-averse, risk neutral or risk loving attitude of the farmer, respectively.

In this study, net revenues from the plots were appropriately rescaled by the assumed farm size of 200 ha of canola to maintain the correct rankings by GSD (Raskin and Cochran 1986). McCarl (1990) has identified the importance of accurate estimation of ARAC when the farmers' risk preferences are unknown. The nonnegative certainty equivalent procedure was used to set approximate upper bounds on ARACs (McCarl and Bessler 1989).

The GSD analysis was conducted using the Simetar risk simulation program (Richardson 2002). Simetar allows ranking of the management decisions based on lower and upper ARACs. During pair-wise comparisons of cumulative distributions of net revenues, risk aversion coefficients associated with the intersection of cumulative density functions were determined. Following McCarl (1988), the ARAC value where dominance changes between pairs of decisions is defined as the Breakeven Risk Aversion Coefficient (BRAC).

DATA

Data were from field experimental plots on Lacombe, Alberta during 1998 to 2000 (Clayton et al 2004). Canola followed a cereal crop in the cropping pattern across all experimental plots. The soil type is black Chernozem clay loam (43% sand, 21% silt and 36% clay), relatively acidic (PH of 5.9), and with relatively high organic matter (8.2%).

The factorial experiment was arranged in a randomized complete block design with four replicates. Factors were canola cultivar, time of seeding, and time of weed control. Canola cultivars were herbicide tolerant (glufosinate-resistant) hybrid 'Invigor 2153' and inbred 'Exceed'. Fall (just prior to soil freezing), early spring (late April or early May), and traditional mid-May were the time of seeding alternatives. Time of weed control was based on canola growth including cotyledon stage, three-leaf stage and six-leaf stage in 1998, but two, four, and six leaf stages in 1999 and 2000.

RESULTS AND DISCUSSION

Average Yields

There was considerable variation in the mean and standard deviation of yields across decisions (Table 1). The mean yield of Invigor 2153 ranged from 2312 to 2859 kg/ha. The mean yields were higher for early spring seeded (2761 to 2859) compared to fall (2312 to 2693) and mid-May (2355 to 2398). Despite higher means, the standard deviations were lower for early spring seeded compared to fall and mid-May seeded Invigor 2153. The yield distributions though were not statistically different using a non-parametric Mann-Whitney test at 5% level. The highest mean yield was observed with early spring seeding and late weed control (2859) with a low standard deviation of 329 kg/ha. The lowest mean yield was associated with fall seeding and late weed control (2312) with a high standard deviation of 859 kg/ha.

The mean and standard deviation of yields also varied considerably across decisions for Exceed. The mean yield ranged from 1885 to 2479 kg/ha. Like Invigor 2153, the early spring seeding mean yield was higher (2424 to 2479) and had a lower

standard deviation compared to fall or mid-May seeding. Fall seeding had the lowest mean yields (1885 to 2089) with a high standard deviation. Unlike the Invigor 2153, yield distributions of early spring were significantly different from fall and mid-May using Mann-Whitney test at 5% level.

Average Net Revenues

The mean and standard deviation of net revenue distributions across eighteen management decisions are given in Table 2. The outcome distributions are also compared statistically using a non-parametric Mann-Whitney test (P=0.05) across cultivars.

The expected payoff and variability differs across decisions for each cultivar. Within Invigor 2153, the mean payoff from early spring seeding with weed control at the six-leaf stage ($638) is the highest and also has a lower standard deviation (111). For the same cultivar, fall seeding with weed control at the six-leaf stage produced the smallest mean net revenue ($420) and a high standard deviation (297). Despite the large differences in means for Invigor 2153, there was no statistically significant difference in net revenue across management decisions.

Exceed also shows substantial variation in the mean net revenue across decisions. The mean net revenue was highest for early spring seeding and weed control at the three to four-leaf stage ($542) with a low standard deviation (99). Fall seeding with weed control at cotyledon to two-leaf stage had the lowest mean net revenue ($314) and a high standard deviation (196). Unlike Invigor 2153, net revenue distributions from early spring seeding were statistically different from fall and mid-May seeding.

The expected payoff from Invigor 2153 was consistently higher than from Exceed. The mean payoff from Invigor 2153 ranged from $420 to $638 per ha with an

average of $521. The mean payoff from Exceed ranged from $314 to $542 per ha with a lower average of $433 per ha. In general, net revenue distributions were also statistically different across cultivars (Table 2). This conforms with the higher yield potential of the hybrid (Table 1), and with other agronomic studies (Harker et al 2001; Starmer, Brown and Devis 1998; Van Deynze et al 1992). However, the higher mean payoff from Invigor 2153 was generally associated with a higher variability of net returns.

The expected net revenues for time of seeding were generally consistent across cultivars. The mean net revenues were consistently higher for early spring seeding compared to mid-May or fall seeding (Table 2). The higher yield potential of early spring seeding in Alberta were also observed from a six site-year study during 1996-1999 (Karamanos, Harapiak, and Flore 2001). Higher yield of early spring seeding in this experiment was attributed to higher plant densities and lower dockage (Clayton et al 2004).

The payoff from time of weed control varied with time of seeding and cultivar. For a time of seeding, the mean net revenue across time of weed control ranged consistently wider for fall seeding, which was $420-$554 for Invigor 2153 and $314-$385 per ha for Exceed. For early spring or Mid-may seeding, the mean net revenue range was small (below $39). A larger range in net revenue was expected during fall seeding due to more variable plant survival and plant density, and the challenge of maintaining plant population compared to spring seeding dates.

Upper Limit Risk-Expected Return Trade-offs

The absolute difference in mean net revenues and upper limit on risk differences were generated from 153 combinations of outcomes from 18 management decisions in this study. A plot of absolute mean differences against upper limit risk differences across groups of decision pairs are shown in Figure 1. The slope of the curve reveals a positive trade-off between *MD* and *URD* for this sample of decisions.

A linear model fits well to the sample data with a high R^2 (0.82). The parameter, *β =0.0022,* is statistically significant from zero at the1% level of significance. The estimate indicate a significant positive marginal response of upper limit risk differences to mean differences for a typical pair of decisions in this sample. The elasticity at the mean was 0.43%, indicating a 1% increase in mean net revenue difference was associated with up to 0.43% higher risk for a typical pair of decisions in the sample.

Stochastic Dominance

The GSD analysis determined dominance of the management decisions, or the ARAC at which the decision would dominate (Tables 3 and 4). Tables were organised following Yiridoe et al (2000). The GSD analysis, in this case, is ranking alternative risky management decisions for groups of farmers with differing risk attitudes. Pair wise comparisons of simulated cumulative distribution functions (SCDF) of nine management decisions for two cultivars of canola are provided. There are two possible outcomes: either one dominates the other or dominance cannot be determined. If a management decision dominates the other through the entire range of given ARACs, then either column donates row (CD) or row dominates column (RD). If the SCDFs intersect, then either column dominates row (BRAC without bracket) or the row dominates column

(BRAC with bracket) above the intersection. The BRAC is the ARAC at which risk dominance changes between a pair of management decisions. Despite a possibility of complete overlap of SCDFs, the possibility of multiple crossovers of two SCDFs is noted in the footnotes of the Table 3.

The GSD rule is more discriminatory for Invigor 2153 compared to Exceed. The lower triangular matrices in Table 3 show more BRACs (18) for Invigor 2153 compared to Exceed (11) when evaluated among a group of individuals whose risk aversion coefficient ranges between –0.0001 to 0.0005. Each BRAC is a reference point that separates decision makers by their risk attitudes. Therefore, BRACs in this sample separated a group of decision makers into 19 subgroups for Invigor 2153 and 12 subgroups for Exceed.

For a typical time of seeding, risk efficiency order of time of weed control differed more frequently across decision makers for Exceed than Invigor 2153. Only 4 BRACs (out of 18) were observed for the intra-time of seeding decisions for Invigor 2153 compared to 11 for Exceed (Table 3). The higher mean numbers of BRACs for Exceed indicate that producers using Exceed will have a more specific preference for a time of weed control than producers using Invigor 2153.

Unlike the order of time of weed control, the risk efficiency order of seeding date remained unchanged across decision makers for Exceed, with early spring dominating. But, four different types of orders were observed for Invigor 2153 (Table 3). Mid-May and fall seeding dominated early spring only if the producer was risk loving. The order of the management decisions changed frequently within the range of risk loving attitudes. The percentage of positive (risk loving) BRACs was much less compared to negative

BRACs for both cultivars. Only 2 of the 18 BRACs were positive for Invigor 2153 (BRAC = 0.000029 between weed control at cotyledon to two leaf stage and three to four leaf stage in early spring seeding, and BRAC = 0.0000029 between weed control at three to four leaf stage and six-leaf stage in mid-May seeding) and 3 of the 11 BRACs for Exceed (Table 3).

Table 4 shows selected GSD ranked orders of management decisions (a complete list of orders can be extracted from Table 3) corresponding to different risk attitudes of the decision makers. The table reveals that the risk efficient management decision differs across risk attitudes and across cultivars. For example, early spring seeding and late weed control dominated among risk neutral or risk averters while mid-May seeding and weed control at cotyledon to two-leaf stage was dominant among risk loving decision-makers growing Invigor 2153.

A producer growing Exceed preferred early spring seeding irrespective of their risk attitude. The preference for time of seeding was early spring, mid-May, and fall. However, the decision on time of weed control varied with the risk attitude. Weed control at the three to four leaf stage dominated late weed control for risk neutral individuals in early spring seeding but the reverse was true for moderate risk lovers and risk averters. The individual had to be more risk averse to prefer weeding at the cotyledon to two-leaf stage with early spring seeding.

In general, fall seeding of Exceed or Invigor 2153 is risk inefficient because they have the lowest net revenue and relatively high variability (Table 2). Fall seeding with weed control at three to four-leaf stage was better than mid-May for a risk-neutral Invigor 2153 canola grower, but it was less risk efficient than early spring seeding.

Management decisions at the risk efficiency frontier across risk attitudes include all stages of weed control. Risk neutral and risk averse producers generally preferred weed control at the late stage (six-leaf stage), except for the risk neutral case for Exceed. Early weed control was only associated with strong risk loving attitude. Results show that risk attitudes of farmer are more likely to affect their preferences for time of weed control compared to time of seeding.

SUMMARY AND CONCLUSIONS

Increasing profitability and reducing income risks are the two major objectives for the canola growers. Income risks due to yield variability were modeled for canola growers in the prairies. Farmers were hypothesised to choose among two cultivars, three times of seeding and three times of weed control before planting canola. In the absence of an exact utility function, stochastic dominance analysis was used to evaluate net revenue distributions from combination of selected decisions. Stochastic dominance analysis was supplemented with statistical analysis of upper limit risk-expected return trade-off.

The average net revenue and variability differed across cultivars, time of seeding and, time of weed control. Results were mainly drawn from yield variation. The expected payoffs from cultivar selection outweighed time of seeding, which exceeded time of weed control. The expected payoff were higher for Invigor 2153 than for Exceed with generally higher variability. The expected payoff from early spring seeding was higher compared to fall and mid-May seeding. For a time of seeding, the expected payoff across time of seeding ranged wider for fall seeding than early spring and mid-May seeding.

The statistical analysis of the sample revealed a significant positive upper limit risk-expected return trade-off (0.002) between a typical pair of decisions. Stochastic dominance analysis indicated that seeding in early spring with late weed control was efficient for a risk-averse farmer. Seeding Invigor 2153 in mid-May with early weed control was competitive for relatively risk loving farmers. A strong risk lover always preferred early weed control. Seeding Exceed in early spring was always dominant over traditional mid-May seeding for all risk attitudes. Irrespective of cultivars, seeding canola in the fall was among the risk inefficient decisions.

The only behavioural attribute considered was risk with regard to income. Farmers may have different objectives like distribution of workload. Premiums or discounts for the quality (% oil) of canola was not included and could have an impact. Future studies might want to account for quality attributes. The experimental plots in this study provided greater homogeneity within treatments, various constraints and opportunities across farms may alter the risk efficient decision for a specific farm. Inferences from limited years of field experimental data from Alberta in this study should only be generalized with caution for other regions.

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Table 1. Mean and standard deviation (kg/ha) of yields across management decisions

Decision	Invigor 2153		Exceed	
	Mean	StDev	Mean	StDev
A2[a]	2820a[b]	365	2424b	328
A4	2761a	256	2479b	313
A6	2859a	329	2472b	334
F2	2379ab	727	1885c	559
F4	2693a	568	2089c	391
F6	2312ab	860	2032c	470
M2	2398ab	660	2044c	455
M4	2355ab	582	2095c	442
M6	2373ab	736	2153c	391

[a] Management decisions: seeding date (A= early spring, M=mid-May, and F= Fall), and weed control stage (2 = cotyedon to 2, 4 = 3 to 4, and 6 = 6 leaf stage of canola).
[b] Distributions across both cultivars with the same lower case letter are not significantly different (Mann-Whitney test P=0.05).

Table 2. Mean and standard deviation ($/ha) of net revenues across decisions

Decison	Invigor 2153		Exceed	
	Mean	StDev	Mean	StDev
A2[a]	625a[b]	123	523b	114
A4	604a	87	542b	99
A6	638a	111	540b	103
F2	444ab	252	314c	196
F4	554ab	195	385c	142
F6	420ab	297	365c	172
M2	477ab	229	390c	162
M4	462ab	202	408c	161
M6	468ab	252	428c	139

[a] Management decisions: seeding date (A= early spring, M=mid-May, and F= Fall), and weed control stage (2 = cotyedon to 2, 4 = 3 to 4, and 6 = 6 leaf stage of canola).
[b] Distributions across both cultivars with the same lower case letter are not significantly different (Mann-Whitney test P=0.05).

Table 3. Breakeven risk aversion coefficients from pair wise comparison of decisions

Invigor 2153	A2[a]	A4	A6	M2	M4	M6	F2	F4
A2								
A4	(2.9E-05)[b]							
A6	RD[c]	RD						
M2	-4.53E-05	-3.1E-05	-5.1E-05					
M4	CD[d]	CD	CD	CD				
M6	-6.6E-05	-3.62E-05	-9.26E-05	CD	2.9E-06			
F2	CD	-4.94E-05	CD	CD	-8E-06	CD		
F4	CD	-3.45E-05	CD	(-3.06E-05)	-8E-05	(-3.65E-05)	(-5.45E-05)	
F6	CD	-5.34E-05	CD	CD	-1.3E-05	CD	CD	-5.5E-05

Exceed	A2	A4	A6	M2	M4	M6	F2	F4
A2								
A4	(-5.1E-05)							
A6	(-7.75E-05)	(-1.91E-05)[e]						
M2	CD	CD	CD					
M4	CD	CD	CD	(-2.33E-05)[f]				
M6	CD	CD	CD	(-3.85E-05)	RD			
F2	CD	CD	CD	CD	CD	CD		
F4	CD	CD	CD	CD	CD	CD	(-5.5E-05)	
F6	CD	CD	CD	CD	CD	CD	(-5.05E-05)[g]	-6.5E-05

[a] Management decisions: seeding date (A= early spring, M=mid-May, and F= Fall), and weed control stage (2 = cotyedon to 2, 4 = 3 to 4, and 6 = 6 leaf stage of canola)
[b] The value is the break even risk aversion coefficient (BRAC). Parenthesis denotes the row dominates the column decision for ARAC greater than this BRAC. Positive and negative BRACs indicate risk averse and risk loving attitudes, respectively.
[c] Row decision dominates column decision
[d] Column dominates row decision
[e] also includes BRAC = (0.0000475)
[f] also includes BRAC = 0.000038
[g] also includes BRAC = 0.0000476

Table 4. BRACs and GSD ranking of selected decisions for two cultivars of canola

Risk attitude	BRACs[b]	1	2	3	4	5	6	7	8	9
					Ranks[a] of management decisions					
Invigor2153										
Risk Loving ↑	-0.0000926	M2[c]	M6	A6	A2	F2	F6	F4	A4	M4
Risk Loving ↑	-0.0000534	M2	A6	A2	M6	F4	F2	A4	F6	M4
Risk neutral ↓	0.0000028	A6	A2	A4	F4	M2	M6	M4	F2	F6
Risk averse	0.00005	A6	A4	A2	M2	M4	F4	M6	F2	F6
Exceed										
Risk loving ↑	-0.000078	A2	A6	A4	M2	M6	M4	F2	F6	F4
Risk Loving ↑	-0.000051	A6	A4	A2	M2	M6	M4	F4	F2	F6
Risk neutral ↓	0.0000375	A4	A6	A2	M6	M4	M2	F4	F6	F2
Risk averse	0.0005	A6	A4	A2	M6	M2	M4	F4	F2	F6

[a] The order of preference ranges from 1 (the most preferred) to 9 (the least preferred).
[b] The BRACs denotes breakeven risk aversion coefficients
[c] Management decisions: seeding date (A= early spring, M=mid-May, and F= Fall), and weed control stage (2 = cotyledon to 2, 4 = 3 to 4, and 6 = 6- leaf stage of plant)
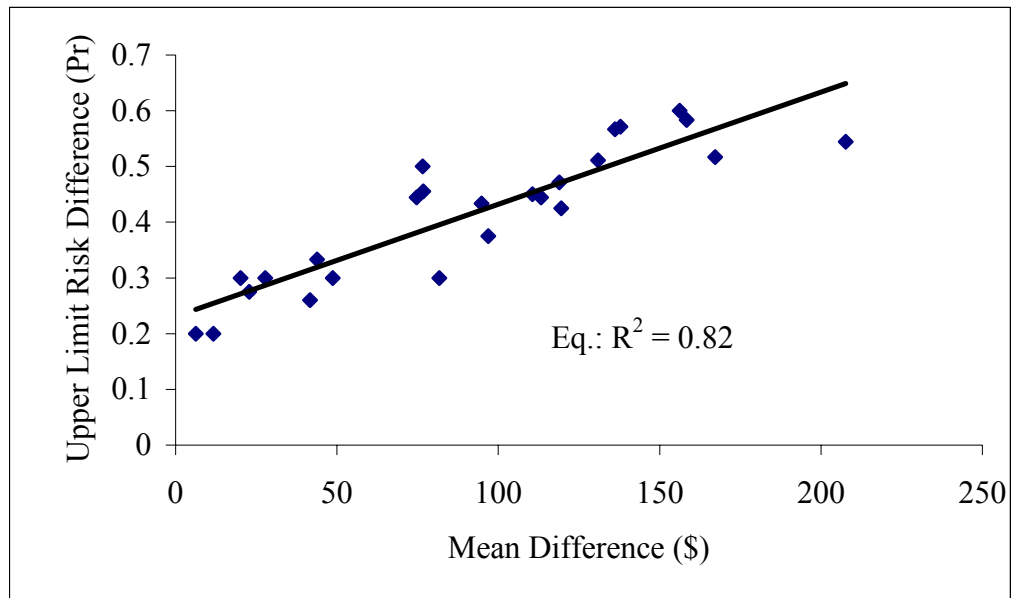
Note: Slope of the trend line, β=0.0022 (P-value = 0.00). Elasticity at mean is 0.43.

Figure 1. Upper limit risk-expected net revenue trade-off in the sample