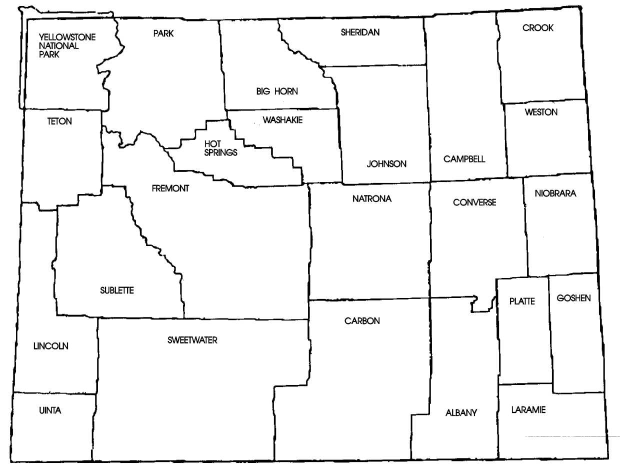
An Economic Evaluation Of The Yield Advantage Of Improved Varieties Of Alfalfa



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Introduction

Improved varieties of alfalfa have greater yield potentials and increased multiple pest resistance (MPR). When managed intensively, yield potentials of improved varieties are frequently 5-20 percent greater[a] than older releases. In general, varieties adapted to Wyoming conditions should be chosen for moderate[a] or better levels of disease resistance to the three most economically important alfalfa diseases[d] in the state: Phytophthora root rot, Verticillium wilt, and stem nematode. These diseases are more problematic on fine-textured soils with gravity-flow, flood irrigation, but are less prevalent or nonexistent, on well-drained coarse-textured soils irrigated with sprinkler systems. Under the latter conditions, the highest levels of MPR are less important. Enhanced MPR may improve stand longevity and hay quality, but yield[f] potentials are more readily quantified.

Research and development costs for improved varieties of alfalfa are factored into retail seed prices. Is the increased yield potential of improved varieties sufficient to warrant higher seed costs? Can substantial increases in net returns be expected from small increases in yield? Where most alfalfa stands in Wyoming are managed for three or more years of hay production, can the potential returns of higher yielding varieties outweigh the costs associated with the improved varieties under various economic conditions and yield assumptions?

Objective

This bulletin utilizes concepts of partial budgeting and time value of money to demonstrate potential net returns from growing improved varieties of alfalfa in place of Ranger, a variety grown in Wyoming since the 1940s. Ranger continues to be produced by many Wyoming hay growers.

Stand Establishment Assumptions

Two University of Wyoming publications concerning alfalfa variety selection[a] and yield trials[c] reveal dozens of high-yielding, MPR varieties adapted to Wyoming growing conditions. Seed prices vary, but this scenario assumes a bulk seed price of $2.85/lb. for a good yielding, adapted variety with adequate MPR. The improved variety in this scenario is hypothetical, but represents a readily available pool of similar varieties with the attributes described above. Bulk seed price of certified Ranger varies, but this analysis assumes a price of $1.85/lb. This example also assumes the use of certified seed to ensure variety pedigree and to avoid noxious weed seed.

The stand is assumed to be stubble-seeded August 5-10 and irrigated immediately. Seedlings emerge within five days due to high soil temperatures, then grow rapidly and advance to the third trifoliolate stage or beyond by September 15. Two additional irrigations are applied before October 1. The stand achieves a height of 4-4.5 inches prior to exposure to a killing frost (23-24 °F for several hours) on October 10. Winter survival of the stand is expected to be good under these conditions.

Alfalfa is sown at 12 lbs. pure live seed (PLS)/acre (A), though some growers establish good stands with 8-10 lb./A. In addition, the alfalfa is seeded into feed grain barley stubble that

was spring-sown and stand-certified as free of noxious weeds by county weed and pest control personnel.

Yield Assumptions

At elevations of 5400 feet or lower in Wyoming, stands of irrigated alfalfa can be intensively managed for three crops per season[b]. With intensive management, Ranger should yield 4-5 T/A of air dry forage[c]. In this example, the costs and returns from Ranger (4.6 T/A) are compared to a conservative increase in yield (1-10 percent) due to using an improved variety.

Additional Cost Related To Establishment Of Improved Varieties

Both Ranger and the improved variety in this scenario have a PLS value of 0.891. Pure live seed is the germination percentage multiplied by the purity percentage of the bulk seed divided by 100, with the result expressed as a decimal fraction. Therefore, a bulk seed planting rate of 13.47 lb./A (12 lb./0.891 PLS) is required to achieve a rate of 12 lb. PLS/A. In this example, total seed cost to establish Ranger at 12 lb. PLS/A is $24.92/A ($1.85/lb. bulk seed @ 13.47 lb./A). Total seed cost to establish an improved variety is $38.39/A ($2.85/lb. bulk seed @ 13.47 lb./A). Thus, the additional per acre seed cost for the improved variety is $13.47/A ($38.39 - $24.92 = $13.47/A). Will the increased yields and returns of the improved variety exceed the additional establishment costs?

Additional Assumptions

Assume the following conditions: (1) Hay will be sold for $65/T. (2) Harvest costs are $29.43/T[e]. (3) Returns from the improved variety are evaluated on the basis of 1, 3, 5, 7 and 10 percent yield increases when compared to Ranger for a six-year period.

One might expect both hay selling price and harvest costs to increase over the six-year period. For clarification, both costs and returns are assumed constant over the six years in this analysis.

Partial Budgeting

The economic feasibility of planting an improved variety is evaluated by partial budgeting techniques. Only four categories of costs and returns are considered: (1) reduced costs; (2) increased returns; (3) increased costs; and (4) reduced returns.

The first two categories of costs and returns contribute to an improved financial position. The last two categories lead to a weakened financial position. Partial budgeting considers only those items that change from the base situation. When considering whether to plant Ranger or an improved variety, only increased returns and increased costs must be considered. All other cost and return factors are assumed to remain constant. Examples of

the cost and return factors which remain constant, regardless of variety, include: seed bed preparation costs, irrigation costs, fertilization costs, planting machinery costs, and labor requirements.

Costs and Returns That Change When Planting An Improved Variety

The following costs and returns can change as a result of planting an improved variety: (1) Investment costs may be greater due to higher seed costs; (2) Harvest costs may increase with higher yields produced by an improved variety; and (3) Gross revenue from hay production may increase with higher crop yields. Details for each expense and revenue item are presented in the partial budget framework below.

Table 1. Added Per Acre Costs and Returns for An Improved Variety of Alfalfa Versus Ranger, Assuming a 5 Percent Increase in Yield Due to the Improved Variety

End of Year	Description	A Reduced Costs per acre	B Added Returns per acre	C Added Costs per acre	D Reduced Returns per acre	A+B-C-D Change in Net Return per acre
0	Cost of seed			$13.47		($13.47)
1	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
2	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
3	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
4	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
5	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
6	Harvest costs			$6.77		$8.18
	Cash returns		$14.95			
	TOTAL	$0.00	$89.70	$54.09	$0.00	$35.61

Table 1 presents scenario information in the partial budget format. Added or reduced costs and added or reduced returns are presented for each year of a six-year stand life. Improvements to net returns (comprised only of added returns in this analysis) are weighed against the offsetting categories (added costs in this case) to calculate added net return for each of the six years. Net return is totaled for all years to arrive at a six-year net return.

The point of the initial decision (year zero) shows an added cost of $13.47/A. This additional expense or change in net return in year zero is the difference in seed cost for the two varieties ($38.39 - $24.92 = $13.47/A).

At the end of year one, added costs are $6.77/A. The $6.77/A added cost results from increased yield due to an improved variety (0.23 T/A increased yield X $29.43/T harvest costs = $6.77/A). Added returns are $14.95/A due to increased yield from an improved variety (0.23 ton/A X $65.00/T = $14.95/A). Thus, the change in net return for years one through six is $8.18/A ($14.95/A added returns less $6.77/A added costs = $8.18/A).

When net returns are summed for years zero through six, total net return is $35.61/A. This is encouraging, but opportunity interest must also be calculated and included in the cost of establishing an improved variety.

Opportunity Interest

Additional investment capital is required to purchase the seed of an improved variety. This capital could be used for alternative investments. "Opportunity interest" is an interest charge calculated for the option of purchasing a more expensive seed. The interest rate used in this calculation should be high enough to cover earnings foregone by not investing in the next best alternative (e.g. savings). These investments could be made either on or off the farm. The interest rate for the next best alternative is used to calculate the cost of investing in seed of an improved variety for the life of the stand.

Economic Feasibility

Alternative investments usually have different cash flows and rates of return. Timing of cash flow differs for alfalfa establishment and native range improvement, for example. Costs, returns, and timing can vary dramatically from one investment to the next. To evaluate the economic feasibility of planting an improved variety, Net Present Value (NPV) and Modified Internal Rate of Return (MIRR) will be calculated for both Ranger and the improved variety. Both methods consider timing of cash flow, opportunity interest, and the other factors necessary to compare these investment alternatives on an 'apples-to-apples' basis.

Net Present Value

NPV yields the net return for investments generating cost and returns at different points in the future. These returns are compared using a common basis, sometimes referred to as "today's dollars." In other words, all future costs and returns for the investment are discounted "back to today" and summed to yield a net return in "today's dollars." This value can be calculated for all investments under consideration in order to identify the most favorable alternative. The greatest net return is shown by the largest positive NPV.

The formula for calculating net present value for an investment:

$$NPV = -INV + \frac{P_1}{1+i} + \frac{P_2}{(1+i)^2} + \ldots + \frac{P_N}{(1+i)^N} + \frac{V_N}{(1+i)^N}$$

INV = the initial investment
P_N = the annual net return for each year of the investment
N = the investment period
i = the interest rate
V_N = the salvage value or terminal investment value (if any)

Demonstration Of NPV Concept

Assume that you have an investment opportunity. Each alternative has the same cost ($100) and the prevailing rate of return is 10 percent. The net return of one option is $100 today or $110 one year from now in the other. Either alternative is satisfactory when the interest rate is 10 percent. Looked at a different way, when the $110 is discounted "back to today," it yields a NPV of $0 (NPV=-100+110/1.10=0). Thus, comparing $100 today with $110 one year from now leaves you equally satisfie with either option, assuming an interest rate of 10 percent.

However, if given the choice of receiving $100 todayversus $115 one year from now, with the prevailing interest rate of 10 percent, you should choose the $115 one year from now. To see this in net present value terms, discount the $115 "back to today's dollars" to get a NPV of $4.55 (NPV=-100+115/1.10=4.55). By comparing the $100 available today with the option of receiving $115 one year from now, you would probably choose the $115 a year from now because the net present valu is greater than zero for an interest rate of 10 percent.

Table 2 compares added costs and returns of the improved variety with Ranger by using the NPV method to evaluate incremental yield increases at different interest rates. A 5 percent yield increase produces a NPV of $35.61 when i = 0 percent, assuming no time value of money (0 percent interest rate). Thus, $35.61 is the same value calculated in Table 1 for the total of all cash costs and returns for the scenario. However, NPV declines when a higher opportunity cost is assumed for the time value of money.

Net present value declines from $35.61/A (for i = 0 percent) to $19.23/A (i = 13 percent) when the improved variety yields 5 percent more than Ranger. However, the NPV increases as yields increase. Yield potentials reported in Table 2 are 1 to 10 percent greater than Ranger. NPV varies from a negative $5.65/A (for a 1 percent yield increase) to a positive

$64.51/A if yields increase by 10 percent (for i = 7 percent). Net present values are negative for all interest rates when yields for the improved variety exceed Ranger by only 1 percent.

Table 2. Comparison of the Per Acre Costs and Returns for Ranger and An Improved Variety of Alfalfa Using the Net Present Value and Modified Internal Rate of Return Methods

Year	Net Return Per Acre @ Improved Variety Yield = Ranger +1%	Net Return Per Acre @ Improved Variety Yield = Ranger +3%	Net Return Per Acre @ Improved Variety Yield = Ranger +5%	Net Return Per Acre @ Improved Variety Yield = Ranger +7%	Net Return Per Acre @ Improved Variety Yield = Ranger +10%
0	($13.47)	($13.47)	($13.47)	($13.47)	($13.47)
1	$1.64	$4.91	$8.18	$11.45	$16.36
2	$1.64	$4.91	$8.18	$11.45	$16.36
3	$1.64	$4.91	$8.18	$11.45	$16.36
4	$1.64	$4.91	$8.18	$11.45	$16.36
5	$1.64	$4.91	$8.18	$11.45	$16.36
6	$1.64	$4.91	$8.18	$11.45	$16.36
NPV (i = 0%)	($3.63)	$15.99	$35.61[1]	$55.23	$84.69
NPV (i = 5%)	($5.15)	$11.45	$28.05	$44.65	$69.57
NPV (i = 7%)	($5.65)	$9.93	$25.52	$41.11	$64.51
NPV (i = 10%)	($6.33)	$7.91	$22.16	$36.40	$57.78
NPV (i = 13%)	($6.91)	$6.16	$19.23	$32.30	$51.93
MIRR (i = 0%)	-5.10%	13.93%	24.05%	31.20%	39.24%
MIRR (i = 5%)	-3.09%	16.34%	26.67%	33.97%	42.18%
MIRR (i = 7%)	-2.28%	17.32%	27.74%	35.10%	43.38%
MIRR (i = 10%)	-1.04%	18.81%	29.36%	36.82%	45.20%
MIRR (i = 13%)	0.22%	20.32%	31.00%	38.55%	47.04%

[1] This value represents the change in net return over the Table 1 value of $35.61/A, with a yield increase of 5% and an interest rate of 0%.

Return on Investment

The modified internal rate of return (MIRR)[f] for an investment is the yield rate or the rate of return earned on dollars invested. This rate of return may be calculated for alternative investments available to the investor. Investments may then be ranked by their respective MIRRs. Higher MIRRs indicate investments with a higher earnings potential.

The modified internal rate of return is calculated by a formula similar to that presented for net present value. The MIRR is the rate that sets NPV equal to $0.00, given a specific reinvestment rate for any dollars earned by the investment. (MIRR[g] differs from the standard IRR in that it assumes dollars earned from the investment are reinvested at a specified reinvestment rate, not the rate of return calculated for the investment under consideration.) Thus, the MIRR is like a "break-even" rate of return for investments. If the

calculated MIRR is greater than the minimum rate of return required, then the investment should be considered favorably. (Such an investement would also yield a NPV greater than $0.) However, solving the MIRR equation requires many iterative calculations and is generally accomplished with the help of a financial calculator or computer.

Table 2 presents the MIRR calculated for increased yields of 1-10 percent and reinvestement rates of 0 to 13 percent. Rates of return vary from a low of -5.10 percent for a yield increase of 1 percent and reinvestment rate of 0 percent, to a high of 47.04 percent for a yield increase of 10 percent and reinvestment rate of 13 percent. MIRR for a yield increase of 5 percent range from a low of 24.05 percent to a high of 31 percent, for reinvestment rates of 0 and 13 percent, respectively. Thus, incremental increases in yield produce higher rates of return on the investment. This is also true for NPV calculations. However, assuming even a moderate 3 percent increase in yield and a reinvestment rate of 5 percent, yields an MIRR of 16.34 percent. This is a substantial return for the investment in the seed of an improved variety.

Implications Of Economic Feasibility

Rates of return for yield increases of 1.4 percent or greater are positive across all reinvestment rates, but additional costs must also be considered. The costs and returns assumed in Tables 1 and 2 include all economic costs related to investment in an improved variety. However, other financial obligations may also result from the investment. These might include: principal payments on any loans related to the investment, interest costs on any additional borrowed capital, additional income taxes resulting from the added earnings, etc. For example, where a 5 percent increase in yield produces a 27.74 percent MIRR for the business, using a reinvestment rate of 7 percent, some portion of the added earnings may be needed to cover these other costs. These other costs would reduce the net rate of return earned on the investment. The relative level of increased costs will vary widely from one situation to the next, depending on the business ownership structure, loan interest rates, etc. Thus, these addional cost items were not considered in the calculations presented in this paper.

Break-even Per Acre Seed Cost For An Improved Variety

In our scenario, seed costs for the improved variety would have to rise substantially to offset the corresponding increase in returns. Table 3 presents the break-even cost per acre of seed, assuming yield increases of 1-10 percent over Ranger and interest rates which vary from 0 to 13 percent. In each case, the break-even per acre seed cost yields a NPV=$0 and a MIRR equal to the interest rate specified. Break-even prices range from a low of $31.48 for a 1 percent yield increase and an interest rate of 13 percent, to a high of $123.08/lb. for a yield increase of 10 percent and an interest rate of 0 percent. For a yield increase of 5 percent, break-even prices ranged from $57.62/lb. to $74.00/lb., for interest rates equal to 13 percent and 0 percent, respectively.

In other words, given a 5 percent yield increase and an interest rate of 7 percent, the break-even price is $63.91/lb. Therefore, the price of the improved variety seed could be as high as

$63.91/lb. and the investment would still yield a 7 percent rate of return on investment (MIRR=7 percent).

Table 3. Break-even Per Acre Seed Cost of An Improved Variety of Alfalfa Seed

Interest Rate	Net Return Per Acre @ Improved Variety Yield = Ranger +1%	Net Return Per Acre @ Improved Variety Yield = Ranger +3%	Net Return Per Acre @ Improved Variety Yield = Ranger +5%	Net Return Per Acre @ Improved Variety Yield = Ranger +7%	Net Return Per Acre @ Improved Variety Yield = Ranger +10%
(i = 0%)	$34.76	$54.39	$74.00	$93.62	$123.08
(i = 5%)	$33.24	$49.84	$66.44	$83.04	$107.96
(i = 7%)	$32.74	$48.32	$63.91	$79.50	$102.90
(i = 10%)	$32.06	$46.30	$60.54	$74.79	$96.17
(i = 13%)	$31.48	$44.55	$57.62	$70.69	$90.31

Impact of Lower Hay Prices On Profitability

What price of hay would offset the investment cost for the improved variety? Table 4 exhibits the break-even price for alfalfa hay calculated for incremental yield increases. For each break-even price calculated, NPV=$0 and the MIRR is equal to the interest rate listed. Break-even prices for alfalfa hay range from $34.32/T for a yield increase of 10 percent and an interest rate of 0 percent, to $102.59/T, for a yield increase of 1 percent and an interest rate of 13 percent. Restricting yield increases to 5 percent gives a break-even price ranging from $39.20/T for an interest rate of 0 percent, to $44.07/T for an interest rate of 13 percent.

Adopting an improved variety of alfalfa is favorable as long as alfalfa hay prices exceed the tabular break-even price. Stated differently, if we assume a yield increase of 5 percent and an interest rate of 7 percent, the break-even price of alfalfa hay is $41.73/T. Thus, if hay prices remain above $41.73/T, investing in an improved variety would yield a rate of 7 percent (MIRR=7 percent).

Table 4. Break-even Price of Alfalfa Hay

Interest Rate	Net Return Per Acre @ Improved Variety Yield = Ranger +1%	Net Return Per Acre @ Improved Variety Yield = Ranger +3%	Net Return Per Acre @ Improved Variety Yield = Ranger +5%	Net Return Per Acre @ Improved Variety Yield = Ranger +7%	Net Return Per Acre @ Improved Variety Yield = Ranger +10%
(i = 0%)	$78.20	$45.70	$39.20	$36.41	$34.32
(i = 5%)	$87.21	$48.67	$40.98	$37.68	$35.21
(i = 7%)	$90.96	$49.91	$41.73	$38.21	$35.58
(i = 10%)	$96.78	$51.86	$42.92	$39.05	$36.16
(i = 13%)	$102.59	$53.83	$44.07	$39.89	$36.75

Summary Of Economic Analysis

In summary, the improved variety generates a higher rate of return than Ranger with only a 5 percent yield improvement. Furthermore, the price of the improved variety seed must become extremely high or the price of hay must drop precipitously to make the improved variety less desireable than a traditional variety. Returns would be even more attractive if good stands can be established with seeding rates of less than 12 lb. PLS/A. The modified internal rate of return calculated in this paper, demonstrates that a 5 percent yield increase earns a 27.74 percent annual return on investment with the use of an improved variety of alfalfa, assuming a capital reinvestment rate of 7 percent.

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[g] $$MIRR = \left[\frac{FV_{CI}}{PV_{CO}}\right]^{\frac{1}{N}} - 1$$

Where:

FV_{CI} = Future value of cash inflows

$$FV_{CI} = \sum_{n=0}^{N} P_n (1+i)^{N-n}$$

PV_{CO} = Present value of cash outflows

$$PV_{CO} = -INV + \sum_{n=0}^{N} \frac{-p_n}{(1+i)^n}$$

P_n = the annual payment

i = the interest rate

INV = the initial investment

N = The investment period