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Maximum Economic Yield vs. Maximum Yield

Paul E. Patterson, Jeffery C. Stark, Bryan G. Hopkins and William H. Bohl

Does applying enough fertilizer to maximize yield make sense given the higher fertilizer prices seen the last two years? Reducing fertilizer can save money, but skimping on fertilizer can also reduce yield, may reduce quality and can leave the crop more susceptible to disease and pests. The amount of fertilizer needed to achieve maximum economic yield (maximize net return) may be less than that needed to maximize yield or total revenue.

Yield and quality suffer when nutrients are deficient, which will negatively impact both the price received and total revenue generated. Fertilizer guidelines developed by University of Idaho are designed to provide the potato plant with the nutrients needed to achieve its yield potential and avoid quality problems. In the past, potato nutrient guidelines have focused primarily on yield and quality parameters. Since fertilizer has historically been relatively inexpensive compared to the crop's value, economics of the fertilizer-yield relationship was not considered. Traditionally, the amount of nitrogen fertilizer needed to achieve maximum yield and maximum economic yield for a high value crop like potatoes were the same. However, this may not be true today considering the substantial increases in fertilizer costs.

Three factors are needed to calculate the amount of an input required to achieve the economic optimum: price of the input, price of the crop, and a production function specific to that input. The production function shows the yield response as additional input is applied. The production function is often the missing factor. The production function used in the analysis presented here is based on potato yield response to nitrogen from UI field trials conducted at Aberdeen, Idaho in 2005 and 2006 by Dr. Jeff Stark. Nitrogen was applied at rates of 0, 90, 180, 270 and 360 pounds per acre. While the trial included six potato varieties, only Russet Burbank is discussed here.

Yield data from the trial was normalized by dividing individual treatment means by the highest treatment mean for that year. This expressed the yield response to nitrogen as a percentage of the maximum yield. The treatment percentages were plotted and a 2nd order polynomial (quadratic equation of the general form $f(x) = ax^2 + bx + c$) was fitted to the plotted data as shown in Figure 1. A quadratic equation provides a good representation of the type of non-linear yield response typical of many crops, including potatoes, where the yield declines after achieving a maximum. This equation was then used to generate potato yields based on nitrogen application rates ranging from 0 to 400 pounds per acre applied in 10-pound increments as shown in Figure 2.

How much nitrogen should be applied to Russet Burbank potatoes? It all depends on your objective, the yield potential of the field and available soil nitrate. Based on UI's nitrogen fertilizer recommendation for Russet Burbank, fields like those used in the Aberdeen study with a yield potential of approximately 400 cwt per acre needs 240 pounds of nitrogen when there is zero soil nitrate available. At 10 ppm soil nitrate, the same field would only need 200 pounds nitrogen. Using the production function from the fertilizer trials, shown in Figure 2, 230 pound of nitrogen should be applied to maximize yield. Total revenue will also be maximized at this application rate. However, it is dollars returned per acre that matters most, not hundredweight produced.

To determine the economic optimum amount of nitrogen to apply, you also need to know the price of potatoes and the price of nitrogen. If potatoes are selling for \$7 per cwt and nitrogen is selling for \$.80 per pound, then no more than 200 pounds of nitrogen should be applied to achieve the economic optimum as shown in Table 1 and Figure 3. This is the point where the net return (total revenue – total cost) is highest. Applying either more or less fertilizer will reduce net returns. Note that the

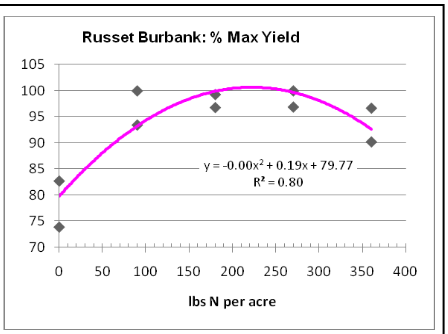

Figure 1. Russet Burbank normalized percentage yield response data points and quadratic equation.

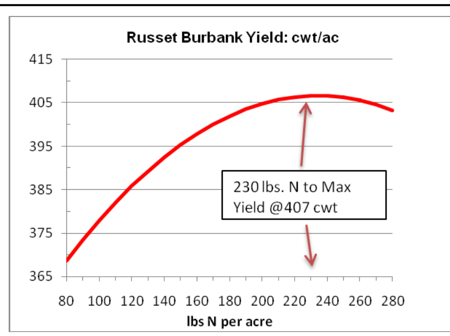

Figure 2. Russet Burbank nitrogen production function generated from quadratic equation.

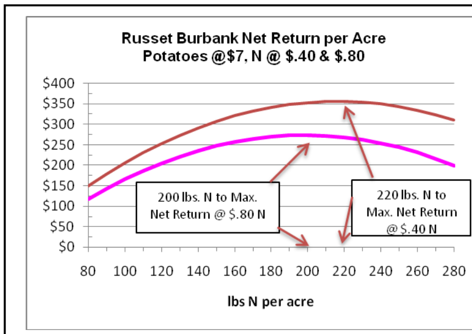

Figure 3. Russett Burbank net return.

Y-axis is now measured in dollars and not cwt. If the price of nitrogen dropped to $.40, the economic mum would be achieved by applying 220 pounds of nitrogen.

Table 1. Russet Burbank maximum economic yield for nitrogen using net returns.

Nitrogen lbs/ac	Total Yield	TR $7/cwt	TC -N	TC+N N=$.80	TR – TC+N Net Return
180	402.0	$2,814	$2,400	$2,544	$270
190	403.6	$2,825	$2,400	$2,552	$273
200*	404.9	$2,834	$2,400	$2,560	$274
210	405.8	$2,840	$2,400	$2,568	$272
220	406.4	$2,845	$2,400	$2,576	$269
230	406.7	$2,847	$2,400	$2,584	$263
240	406.6	$2,847	$2,400	$2,592	$255
250	406.3	$2,844	$2,400	$2,600	$244
260	405.6	$2,839	$2,400	$2,608	$231

TR = Total Revenue
TC-N = Total Cost, minus the cost of nitrogen
TC+N = Total Cost + the cost of nitrogen.
*Maximum economic yield is achieved by applying 200 lbs nitrogen, when potatoes = $7/cwt and N = $.80/lb.

Is it really that simple? Yes and no. Yes if you know the price of nitrogen, the price you will get for your potatoes and you have a production function for the potato variety you are growing. But the production function does not show yield impacts based on interaction between inputs (water and fertilizer for example), variation in yield based on timing of the fertilizer applications, variation in yield response both within and between fields, and the impact of nitrogen rates on potato quality. Because of these plicating factors, it is virtually impossible to precisely calculate the amount of nitrogen to apply to achieve the economic optimum with 100 percent certainty.

Table 2. Nitrogen application rates to achieve maximum economic yield as a percent of the rate to achieve maximum yield for Russet Burbank as price of nitrogen and potatoes vary.

N ¢/lb	---------- Potato Price ----------				
	$5	$6	$7	$8	$9
0 – 25	95%	98%	100%	100%	100%
26 - 50	93%	93%	95%	95%	95%
51 – 75	88%	91%	91%	93%	93%
76 - 100	84%	86%	88%	91%	91%
101 - 125	79%	84%	86%	88%	88%

Note: values are based on the highest value in the price range of nitrogen.

The point we want to make is best illustrated in Table 2 which shows approximately what percent of the nitrogen needed to maximize yield should be applied to attain the maximum economic yield based on different prices for potatoes and nitrogen. The percentages were calculated using the high end of the nitrogen price range. The quantity of nitrogen required to achieve the maximum economic yield and the maximum yield are the same only when potato prices are high and nitrogen is relatively inexpensive. While this situation existed for many years, it is no longer true today.

The take-home message here is at least two-fold: 1) nitrogen management is important even when potato prices are high relative to the price of nitrogen, and 2) nitrogen application rates need to be reduced when fertilizer prices are high or potato prices are low in order to achieve the economic optimum. Growers should base fertilizer rates on soil tests and fertilizer recommendations supported by scientific data. But those rates will need to be adjusted based on field-specific situations, the price of potatoes and the cost of nitrogen. A knowledgeable agronomist familiar with rate response should be consulted when making input decisions. In addition, when reducing fertilizer rates due to high costs, growers need to understand that there are increased risks to their crop, especially when it comes to N fertilizer applications. Do not ignore these risks and make your N fertilizer application decisions accordingly.

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Editor
William H. Bohl, Ph.D.
UI Extension Educator
wbohl@uidaho.edu

Associate Editor
Phil Nolte, Ph.D.
UI Potato Seed Specialist
pnolte@uidaho.edu

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Potatoes were the first food grown in space aboard space shuttle Columbia in 1995.

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