449

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Optimal Nitrogen Fertilization of Dryland Wheat

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Introduction

Fertilizer nitrogen (N) costs have increased nearly 35% in the last 5 years in the Central Great Plains region (CGPR). With that increase in fertilizer cost, farmers have also experienced a decrease in dryland crop yields due to drought. The question then becomes "should optimal N fertilizer rates be less in dry years with low yields" and if that is the case "how much less"? Another consideration is "how does optimum fertilizer N rate change with wheat price and N cost"? In this manuscript, we evaluate dryland winter wheat yield response to applied N over a four-year period and calculate optimal N rates with changing wheat price and N costs.

Methods

Wheat in a winter wheat-summer fallow, reduce–till system, was fertilized at 0, 30, 60 and 90 lbs of N per acre on a Weld silt loam soil. Fertilizer was applied in a preplant broadcast application as ammonium nitrate. Soil samples (top 2 feet) were collected from each plot at planting time before fertilization and after wheat harvest each year. Wheat yield was measured (Fig 1a), relative wheat yield was calculated by normalizing each year's wheat yield data on the maximum yield measured in a given year (Fig 1b) and a response function was fitted to that data to determine the economically optimum N rate (Eq [1]). This allowed us to use data that varied from year to year all in one equation (Fig 1b). We then inserted the economics of fertilizer costs at \$0.37/lb of N and inserted a price of wheat at \$3.72/bushel, \$4.72/bushel and \$5.72/bushel. A production cost estimate of \$54.3 for winter wheat-millet-fallow was then used as a production cost estimate to develop Eq [2]. Equation 2 was then optimized for different yield scenarios and costs of N to develop table 1 and table 2.

Eq [1] Relative wheat Yield = $84.67875 + 0.46388N - 0.00356N^2$

Where N is lbs of N per acre and Relative wheat yield is a number between 0 and 100 (R^2=0.78).

Price of N is \$ 0.37-0.38 per lb actual (UAN at \$240/ton and Urea at \$341.5/ton). Wheat price set at \$3.72/bushel (10 year ave price for January wheat). Assume production costs of \$54.3 for WMF.

Eq [2] Net returns = (a +bN -cN2) * maxyd * Price -0.37N - 54.3

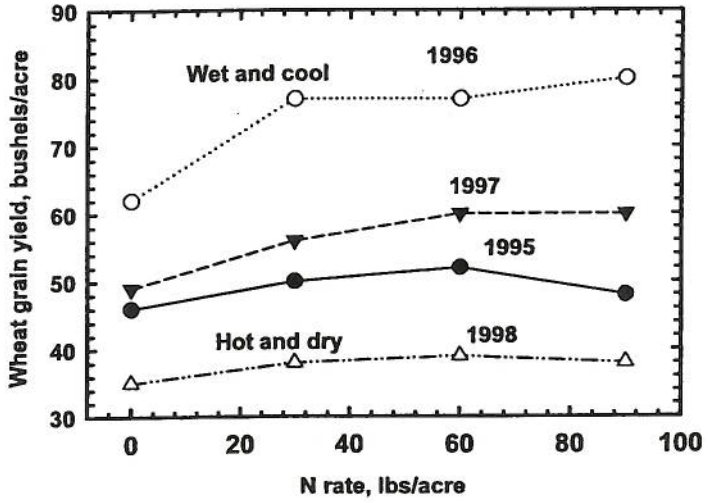
where,

Net returns:	is in \$ per acre
a:	is the y intercept of the N response function (84.67875)
b:	is the linear slope of the response function (0.46388)
c:	is the quadratic slope of the response function (0.00356)
maxyield:	is the wheat grain yield range you are concerned with
Price:	is the grain price in \$ per bushel (\$3.72).
0.37 :	is the price of fertilizer N in \$ per lb of N
54.3:	is the production costs for wheat in WMF in \$ per acre

RESULTS

Wheat yield response varied from year to year and was correlated to rainfall and temperature during the growing season (Fig 1a). However, after calculating relative yield the response to N was observed to be similar irrespective of year (Fig 1b). Maximum yield was calculated at 65 lbs of N per acre. However, farmers are more interested in maximizing net returns than in maximizing yield. The data in table 1 provides calculated optimum N rates based on these data (Fig1a) where maximum net returns are expected for various yield ranges and wheat prices.

a



b

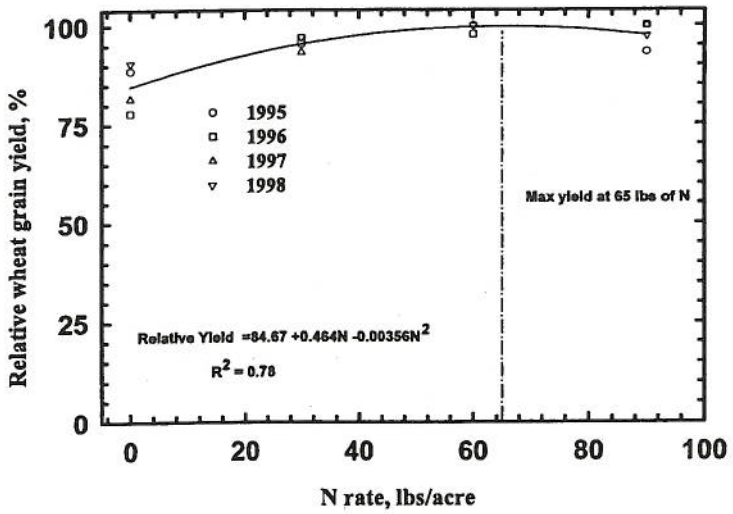


Fig 1. a) Wheat yield as a function of N rate, b) Relative wheat yield as a function of N rate.

Table 1. Economically optimum fertilizer N rate (the fertilizer rate at which maximum net returns are expected) for various yield ranges and wheat prices. Residual N is 20-40 lbs in the top 2 feet of the soil profile. Wheat prices used are $3.72, $4.72 and $5.72 per bushel.

	yield range		$3.72		$4.72		$5.72
Climate	bushels/acre		---------- optimum N rate, lbs/acre ----------				
dry years	15		0		0		5
	20		0		10		20
	25		9		21		29
average years	30		19		28		35
	40		30		38		42
	45		34		41		45
wet years	50		37		43		47
	60		42		47		50
	70		45		49		52

* This table is based on the data analyzed at Akron and is not universal in its application. The array of optimum N rates decreases with a decrease in yield potential and at lower wheat prices.

For dryland wheat, in dry years the optimum fertilizer N rate is less than 20 lbs with our soils and residual N levels of 20-40 lbs. For average years, a reasonable N rate is about 20-35 lbs. However, with 45 bushel wheat at $5.72 per bushel, the economically optimum N rate increases to 45 lbs. In high yield years, the economically optimum N rate (the N rate where net returns are maximum) is still in the 40-50 lb range. It never reaches the "maximum relative yield range", which we calculated to be at 65lbs of applied N. Because it is difficult to know if a year is going to be dry/hot or wet/cool it might make sense to fertilize for the average conditions with 30-40 lbs of N most years (table 1). We also generated a table of optimum N rates where we assumed an additional 30% increase in fertilizer prices (table 2). In a Table 2 we see a decline in optimum N rate that is most dramatic in dry years.

Table 2. Economically optimum fertilizer N rate when residual N is 20-40 lbs in the top 2 feet of the soil profile at 3 different wheat prices of $3.72, $4.72 and $5.72 ($/bushel). Here we assume a 30% increase in fertilizer cost (N cost =$0.49/lb).

	yield range	$3.72	$4.72	$5.72
Climate	bushels/acre	optimum N rate, lbs/acre		
dry years	15	0	0	0
	20	0	0	5
	25	0	7	17
average years	30	3	17	25
	40	19	29	35
	45	24	33	38
wet years	50	28	36	41
	60	34	41	45
	70	39	44	48

Concluding remarks

These tables are helpful in interpreting the general economic relationships with respect to wheat yield and N rate but are not a substitute for soil testing from a reputable soil test lab. The tables do represent a reasonable guess at N fertility needs for winter wheat planted in dryland-silt loam soils in the CGPR. The analysis indicates that the economically optimum N rate decreases (as might be expected) when yield potential is low and when wheat prices are low. The N rate that is needed to maximize net returns is always less than that needed for maximum yield. Even at the highest yield potential (70 bushel) the calculated optimum N rate is at least 15 lbs less than the N rate required for maximum yield. This analysis is based on data collected from a wheat-fallow reduce-till rotation. We have other N rate response data that we intend to include in the analysis collected from other rotations. We are curious how much the optimal N rate relationships might change with wheat-legume-green fallow, wheat-corn-millet-fallow, and wheat-corn-sunflower-fallow.