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DETERMINING AN ECONOMIC FERTILITY LEVEL

Norm Toman, Jay Fisher, and Frank Sobolik

Three steps are involved in determining a maximum economic level for fertility in crop production:

Step 1: Select a yield goal
Step 2: Determine existing fertility level (soil test)
Step 3: Determine additional fertility needed to meet yield goal.

SELECTING YOUR YIELD GOAL

A yield goal describes the yield **potential** for a particular crop considering the climate of your area and the field where it will be grown. Its purpose is to help determine a level of fertility that will maximize profits. Your yield goal should consider both fertility and moisture requirements of the crop being grown.

Three different methods of choosing a yield goal are described in this publication:

— Based on moisture availability
— Using 90 percent of past maximum yield
— Using past average yield plus 35 percent

Moisture Availability

Moisture is most often the most yield-limiting factor. Since total moisture available includes both stored soil moisture and expected growing season moisture, both need to be estimated.

Stored Soil Moisture

Estimates of stored soil moisture can be made by using a soil probe or by checking soil moisture maps published by the NDSU Extension Service in the fall and spring of each year. These maps show approximate stored soil moisture for general areas of the state based on soil probe tests taken about every 25 miles. (See appendix 1 for more details on how to estimate stored soil moisture).

If you're unfamiliar with soil moisture probes, your county agent should have one that he could demonstrate for you. Tests **should** be made of each field.

Rainfall Probabilities

While the state's growing season rainfall tends to increase from northwest to southwest, a rule of thumb is that we can expect 6 or more inches of growing season moisture at least 70 percent of the time. We can also expect 8 or more inches 50 percent of the time. Rainfall probabilities based on research are shown in appendix 2.

Response of Crops to Moisture

Research has provided information on response rate to moisture for many crops. In general, it takes about 5 inches of moisture for these crops to grow the straw needed to begin producing grain. In other words, to measure response to moisture in terms of grain yield, we first subtract 5 inches of moisture from the total available. This 5 inches of moisture should be called a "base" amount.

After subtracting the base, the **approximate** response rate to remaining available moisture for these crops is:

Crop	Yield Response Rate to Moisture
Spring Wheat/Durum	6 bushels per inch
Winter Wheat	7 bushels per inch
Barley	8 bushels per inch
Sunflower	190 pounds per inch

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North Dakota State University, Fargo, ND 58105

Example

An example of developing a yield goal by the available moisture method is illustrated below. In this example, with 4 inches of stored soil moisture and a 50 percent chance of 8 or more inches of growing season moisture, the resulting yield goal is 42 bushels per acre.

Total Moisture (Inches)

Stored	+	Expected Rainfall	=	Total	—	Base	=	Available Moisture	x	Bus./ Inch	=	Yield Goal
4	+	8	=	12	—	5	=	7	x	6	=	42

*Base = amount of moisture required to grow the straw necessary to produce grain and obtain a measurable yield from a crop.

A blank worksheet using the same format as this example is included in appendix 3.

Past Maximum Yield

Choosing a yield goal by the past maximum yield method involves considering the top yields in the past from your land or from your neighbors' land that is similar to yours. Using 90 percent of past maximum, rather than the actual maximum, may be more practical if capital is limited.

A drawback to this method is that past maximum yield may not have been as high as it could have been. Fertility, weed competition, insects, disease, variety choice or other factors may have limited production. Often, the true potential of a field is not reflected in its history.

Past Average Yield

Another method of selecting a yield goal is to select a yield goal that reflects your average yield from that field plus 35 percent. This method takes into account both historic production and additional potential production that is available in some years.

One drawback to this method is that it does not provide consideration of moisture availability. Some years you may want to provide additional fertility for increased yield potential if stored soil moisture is relatively high or choose to cut back if stored soil moisture is low.

Adjusting Your Yield Goal

Your yield goal should reflect the potential of your crop ground under ideal conditions. If you are hitting your yield goal under less-than-ideal conditions, you should adjust it upwards.

EXISTING FERTILITY

Before determining fertilizer needed to meet your yield goal, you must have some idea of how **much** you need. The only way to obtain a reasonable estimate of needed fertility is to estimate what is already available in the soil. The only way to obtain a reasonable estimate of existing soil fertility is through soil testing.

Soil testing involves taking a **representative** sample from **each** field, drying the sample and sending it to a soil testing lab. The sample can be taken by you and sent in or you can hire the sampling done commercially.

If you choose to take the sample yourself, your county agent can advise you on the proper technique. Ask your agent for a fact sheet called "Sampling For Soil Testing," Department of Soil Sciences Research Report Number 8, dated April 1984.

ADDED FERTILITY NEEDED

The primary nutrients required by most North Dakota crops are nitrogen and phosphorus. Some fields will also require either potassium, sulfur chloride or trace elements. Extensive field research in North Dakota has identified response rates of most of our crops to these nutrients. For example, wheat requires about 2½ pounds of nitrogen for each bushel produced. A publication showing nutrient requirements by crop type is available through your county agent. Ask for SF-882, "North Dakota Fertilizer Recommendation Tables and Equations Based on Soil Test Levels and Yield Goals."

Of all the nutrients, nitrogen probably is the most important. It is also one that is commonly underutilized by many North Dakota farmers.

Following is an example how a soil test and yield goal for spring wheat would be used:

Pounds Per Acre

	Nitrogen	Phosphorus	Potassium
Total fertility needed for yield goal (40 bu.)	100	(See table recommendations)	
Soil test	60	8	450
Need to add: (Lbs. nutrients/ Acre)	40	35	0

Generally nutrients not used by the crop in one year will still be available for future crops. Nitrogen can be an exception if you have:

1) fairy coarse soil — in other words, low water holding capacity **and**

2) enough moisture to leach the nutrient through the soil profile.

Phosphorus and potassium are immobile and unused nutrients are generally carried forward.

Additional phosphorus needs should be determined directly from the recommendation tables. Recommendations for phosphorus are based strictly on soil testing. Economics suggest that if your soil test shows:

1) less than 10 pounds per acre:

You can't afford **not** to apply phosphorus! You won't get the benefit of nitrogen fertilizer application if phosphorus is limiting.

Many North Dakota soils are deficient in phosphorus.

2) 10 to 19 pounds per acre:

You might get by without applying additional phosphorous, but you would often benefit by applying the amount specified in the recommendation tables (Extension Circular SF 882).

3) 20 to 29 pounds per acre:

Most of the time you will not benefit (in the current year) from additional phosphorus if your yield goal is less than 50 bushels per acre.

4) 30 or more pounds per acre:

You would probably not benefit (in the current year) from additional phosphorus.

Banding phosphorus with the drill at seeding or with a tillage implement are considered the most efficient methods of applying phosphorus as it is more available to the crop if banded. Early season uptake is more efficient when phosphorus is banded.

A worksheet for computing additional fertilizer needs is included in appendix 4.

COST OF AN ERROR

There is cost involved in underfertilization as well as overfertilization. The cost of either are best described by an example.

Example

Consider the difference in costs and returns between a 30 vs. a 40 bushel yield goal for spring wheat. Added **potential** returns are:

Costs and Potential Returns

Potential Returns (10 bu. wheat @ $3/bu.) =	$30.00
Cost of additional N (25 lb. @ $0.10 per lb.) =	- 2.50
Added cost of application	- .50
Net	$27.00

As you make this comparison for yourself for the current year, you would need to use your own price forecast for grain and your own cost of production for cost of N plus cost of application. If you are already planning to apply some nitrogen, the **added** cost of applying a slightly higher rate may be minimal or even zero.

Potential added net returns in this example are $27 per acre. The cost of the two possible types of error are:

1) If you fertilize for 30 bushels per acre and get 30 bushels (when 40 was possible) you give up the **chance** to make an additional $27 per acre.

2) If you fertilize for 40 bushels per acre and get only 30 bushels,

A. If the nitrogen leaches away (coarse soil and excess rainfall), then the **cost** = $3 per acre.

B. If the nitrogen doesn't leach away (medium and finer soils **or** coarse soil without excess rainfall), then the cost = $3 per acre times the cost of money for one year. If the cost of money was, for example, 12 percent, then cost = $3 x .12 = $0.36 per acre.

In Case A, you are betting $3 per acre against the chance to make $27 per acre.

In Case B, you are betting $0.36 per acre against the chance to make $27 per acre.

ADDITIONAL CONSIDERATIONS

Protein Content

An additional consideration when picking a yield goal for spring wheat is the effect of nitrogen on protein content. When the wheat plant starts to run out of nitrogen, protein production is decreased. This is particularly important in years when protein premiums are relatively high.

Two hindsight measures of whether you "did right" by your fertility program are: 1) if you see starchy "yellow-belly" kernels in your harvested wheat and/or 2) if protein content was less than 14 percent (for the higher protein quality type grains) you may have lost income not only in yield but also on protein premium.

Recrop

Your recrop ground will generally yield as well as your summerfallow ground if the following are equal to your summerfallow ground.

1. Stored soil moisture
2. Weed control
3. Disease control
4. Fertility

SUMMARY

Your maximum economic level of fertilizer use can be determined by:

1: Selecting a yield goal
   —based on moisture availability
   —using 90 percent of past maximum yield
   —using past average yield plus 35 percent

2: Determining existing fertility level (soil test)

3: Determining additional fertility needed to meet yield goal

REFERENCES

1. Brown, Paul L., A. L. Black, Charles M. Smith, John W. Enz and Caprio, "Soil Water Guidelines and Precipitation Probabilities", Montana State University, Cooperative Extension Bulletin 356, March 1981.

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4. Gregoire, Terry and Carl Fanning, "Application of Nitrogen and Phosphorus Fertilizer Products", North Dakota State University, Cooperative Extension Service Circular SF-730, March, 1981.

5. Kresge, Paul and Jim Bauder, "Fertilizer Questions", Montana State University, Cooperative Extension Service Bulletin 1269 (Revised), SF-875 March, 1986.

6. Swenson, L. J., W. C. Dahnke and D. D. Patterson, "Sampling For Soil Testing", North Dakota State University, Dept. of Soil Science Research Report No. 8, April, 1984.

7. "Soil Fertility Manual", Potash and Phosphate Institute, Atlanta, Georgia, Eighth Printing, February, 1985.

Appendix 1
Estimating Stored Soil Moisture

The depth a soil moisture probe can be thrust into the ground indicates moist soil depth. For example, if the probe can be pushed down 2 feet, then there are 2 feet of moist soil available for plant growth at that site.

How many inches of moisture are available in the 2 feet of moist soil depends on soil type. For a quick rule of thumb, medium and fine textured soils will hold about 2 inches of water available for plant growth in each foot of soil. More information is given in Table 1.

Montana and North Dakota

Table 1. Approximate plant-available water per foot of moist soil and depth of moist soil needed for various amounts of available water.

Texture Class	Texture	Plant-available water/ft. of moist soil	Depth of moist soil for avail. water of		
			2 in.	4 in.	6 in.
		in./ft.	in.	in.	in.
Coarse	Fine sand loamy sand	0.8	30	60	90
Mod. Coarse	Sandy loam fine sandy loam	1.5	16	32	48
Medium Fine	Loam, silt loam clay loam silty clay loam silty clay, clay	2.0	12	24	36

Example: There are 3 feet of moist, moderately coarse-textured soil —
Plant-available water: 3 x 1.5" = 4.5"

Following are some characteristics of each group:

Coarse: Feels and sounds distinctly gritty, many particles are coarse. When pressed by the thumb it does not retain a clear print and crumbles easily.

Moderately Coarse: Feels and sounds gritty but particles are relatively fine. Contains enough silt and clay to hold a shape when pressed between thumb and fingers.

Medium Fine: When moist sample is pressed and ribboned between thumb and forefinger, it forms a ribbon, varying from weak (loam and silt loam) to strong (silty clay to clay). When squeezed, the sample takes a firm shape. Clay makes the sample feel sticky; silt gives a smooth, floury feel.

(From: "Soil Water Guidelines and Precipitation Probabilities for Barley and Spring Wheat in Flexible Cropping Systems in Montana and North Dakota", Extension Bulletin 356, March 1981, Montana State University.)

Appendix 2

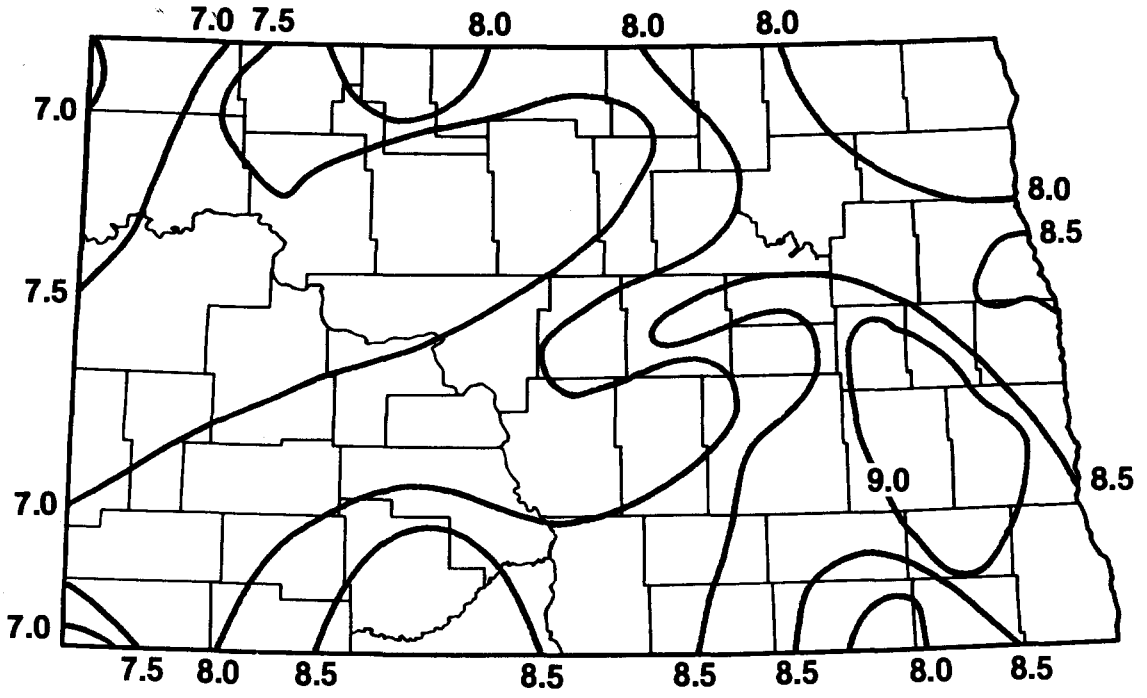

Figure 1. Precipitation amounts for North Dakota that are equalled or exceeded in 50 % of the years during the May 3-August 1 period.

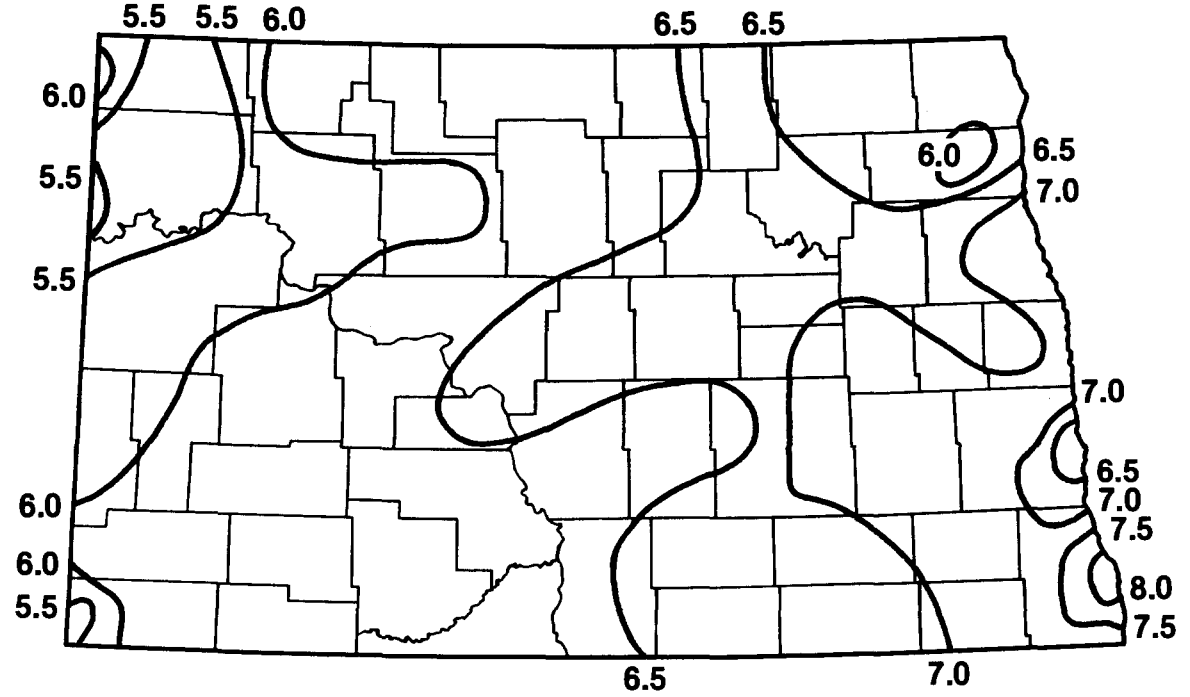

Figure 2. Precipitation amounts for North Dakota that are equalled or exceeded in 70 % of the years during the May 3-August 1 period.

Worksheet

Appendix 3

Selecting Yield Goal by Moisture Availability

Total Moisture (Inches)

Stored	+	Expected Rainfall	=	Total	—	Base	=	Available Moisture	x	Bus./ Inch	=	Yield Goal
_____	+	_____	=	_____	—	5	=	_____	x	_____	=	_____
_____	+	_____	=	_____	—	5	=	_____	x	_____	=	_____

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Research shows response rates to moisture as approximately:

Spring Wheat
& Durum Yield = (stored moisture + precipitation) (—5) x 6 bu./in.

Winter Wheat Yield = (stored moisture + precipitation) (– 5) x 7 bu./in.

Barley Yield = (stored moisture + precipitation) (—5) x 8 bu./in.

Appendix 4

Fertility Worksheet

Field # _____ Crop _____

Yield Goal (1) _____

	Lbs. N	Lbs. P	Lbs. K
Total Amount Needed:	(2a)	(2b)	(2c)
Soils test:	(3a)	(3b)	(3c)
Needs to add:	(4)	(5)	(6)

Worksheet Instructions:

(1) Enter the yield goal you have developed for this specific field.

(2) Go to the recommendation tables and enter amounts of N, P and K needed for the yield goal indicated.

(3) Enter the amounts of N, P and K that exist in this field, as indicated by the soil test for this field.

(4) Subtract the amount shown in the soil test from total N needed. (subtract the amount on line 3 a from the amount on line 2a and enter the difference on line 4).

(5) If P is needed at all, add entire amount shown in recommendation tables. Do **not** subtract soil test amount.

(6) Most North Dakota soils are very high in K and, in that case, none will be needed. If K is needed at all, add entire amount shown in recommendation tables. Do **not** subtract soil test amount.

To determine correct application amounts, you will need to convert pounds of product to pounds of actual nutrient. The product 18-46-0, for example, contains 18 percent nitrogen, 46 percent phosphorus and 0 percent potassium. Applying one 50 pound bag of this product per acre means you have applied 9 pounds of nitrogen (50 x .18 = 9), 23 pounds of phosphorus (50 x .46 = 23) and 0 pounds of potassium.

Helping You Put Knowledge To Work

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