

North Dakota Fertilizer Recommendation Tables and Equations

Based on Soil Test Levels and Yield Goals

D.W. Franzen

Extension Soil Specialist

Contents

Table 1. Soil test calibration levels used in North Dakota	5
Nutrient Recommendations	
Table 2. Alfalfa	5
Table 3. Barley, feed	5
Table 4a. Barley, malting in cooler, moister climates	6
Table 4b. Barley, malting in warmer, drier climates	6
Table 5. Buckwheat	6
Table 6. Canola	7
Table 7. Clovers (alsike, red, birdsfoot trefoil, grass-legume)	7
Table 8. Corn, grain and popcorn	7
Table 9. Corn, silage	8
Table 10. Corn, sweet	8
Table 11. Crambe	8
Table 12. Dry bean (pinto, navy, other)	8
Table 13. Flax	9
Table 14. Forage/hay grasses, established, irrigated, new seedings, native grass	9
Table 15. Millet and canary seed	9
Table 16. Mustard	9
Table 17. Oat	10
Table 18. Pea, field, lentil and chickpea	10
Table 19. Potato	10
Table 20. Safflower	10
Table 21. Sorghum, grain	11
Table 22. Sorghum, forage, sudangrass	11
Table 23. Soybean	11
Table 24. Sugar beet	11
Table 25. Sunflower	12
Table 26. Wheat, spring, durum, winter and rye	12

The following soil test recommendation tables are based on field research data obtained in North Dakota, South Dakota, western Minnesota and the Canadian Prairie Provinces.

In the case of some crops, data in the literature also were used to supplement data available from this area.

These tables were developed in cooperation with South Dakota State University and the University of Minnesota under the Tri-State Recommendation Program. Note that phosphorus and potassium soil test results in these tables are in parts per million (ppm). Parts per million times two is equal to pounds per acre for a 0- to 6-inch deep sample core. This conversion will help interpretation of data from laboratories that provide results in units other than ppm.

This publication contains changes from previous publications. Please dispose of older editions.

Changes in comparison to previous tables were made based on new or re-evaluated data.

The major changes are:

1. Dry bean nitrogen (N), phosphorus (P) and potassium (K) recommendations
2. Malting barley N recommendations in drier, warmer areas (mostly in the west)
3. Canola N recommendations

Recommendation Tables

Fertilizer needs should be determined after carefully evaluating the current fertility level of the soil and the nutrient needs of the crop to be grown, and setting realistic yield expectations. We strongly suggest that yield expectations be based on yield potential for a field or a region. Recent research has shown that more productive areas of fields require less fertilizer, particularly N, than less productive areas of the field because they tend to be higher

NDSU
Extension Service

North Dakota State University
Fargo, North Dakota 58105

MAY 2007

in organic matter and have a higher seasonal moisture content. The exception to this would be saline areas that commonly are high in residual N. Several of our N recommendations are “capped” at a maximum rate. In years that support higher yields than our N recommendation formulas indicate, our data show that greater N release from the soil will support these higher yields without requiring additional supplemental N fertilizer.

Nitrogen

Nitrogen (N) recommendations for all crops except some legumes are based on the amount of nitrate-N ($\text{NO}_3\text{-N}$) in the top 2 feet of soil and the yield potential. Nitrogen fertilizer recommendations are not adjusted based on method of placement, but are adjusted for previous crop and depth of sampling. To determine the amount of recommended fertilizer N, subtract the amount of $\text{NO}_3\text{-N}$ in the soil as determined by soil test and N-credit from the previous crop, if applicable, from the total amount of available N needed for a particular yield goal and crop.

An Example

Your NDSU soil test shows that you have 55 pounds of $\text{NO}_3\text{-N}$ present in the soil to 2 feet. Your yield potential is about 40 bushels per acre (bu/A) of spring wheat. The amount of nitrogen recommended to support a 40-bushel yield is 100 pounds of N/acre. The difference between 100 pounds (from the N fertilizer recommendation table for wheat) and 55 pounds (the soil test) is 45 pounds of N. Therefore, the N recommendation is 45 pounds of N/acre.

Adjusting N Recommendations

In a preplant $\text{NO}_3\text{-N}$ soil testing program, certain adjustments need to be made for the apparent contribution of N from some previous crops:

Previous Crop N Credits

Some crop residues have a lower carbon/nitrogen ratio (C/N ratio) than others, which results in a release of plant-available N through rapid decomposition. Also, the mass of residue of some crops is smaller than others (dry bean compared with wheat or corn, for example). Evidence also shows that some crops (soybean) may accelerate the normal N mineralization rate from organic matter. Nitrogen availability is greater after crops with lower C/N ratio (sugar beet,

alfalfa) and crops having a lower mass of residue (soybean, dry bean) with less ability to tie up N during decomposition. We suggest that the following N credits be subtracted from crop N recommendations.

Credits

Previous crop	Credit
Soybean	40 lb N/acre
Edible bean	40 lb N/acre
Pea and lentil	40 lb N/acre
Chickpea	40 lb N/acre
Sweet clover that was harvested	40 lb N/acre
Alfalfa that was harvested and unharvested sweet clover:	
>5 plants/sq ft	150 lb N/acre
3-4 plants/sq ft	100 lb N/acre
1-2 plants/sq ft	50 lb N/acre
<1 plant /sq ft	0 lb N/A
Sugar beet	
Yellow leaves	0 lb N/acre
Yellow/green leaves	30 lb N/acre
Dark green leaves	80 lb N/acre

Second Year N Credits

Half of credit given for the first year for sweet clover and alfalfa, none for other crops.

Depth Adjustments

The original data for calibration of the $\text{NO}_3\text{-N}$ test was based on soil samples taken to a depth of 5 feet. Sampling beyond 2 feet improved nitrogen recommendations somewhat, but in the late 1960s, researchers decided that the extra effort to sample to a depth of 3 or 4 feet was not practical or necessary for most crops. Drought and application of excess N, however, may result in a buildup of available N below 2 feet. When fields are tested for N each year and only the recommended amount of N is applied, an accumulation of nitrogen below 2 feet is unlikely.

Sugar beet is the most likely crop to be sampled to the 4-foot depth, but adjustments are not necessary in N calculations. Recommendations for sugar beet for 2-foot and 4-foot sampling are given in Table 24. If deeper sampling is conducted to refine recommendations or screen for problems in malting

barley, sunflower or safflower, the following adjustments would apply:

1. If the amount of $\text{NO}_3\text{-N}$ in the 2- to 4-foot depth is less than 30 pounds $\text{NO}_3\text{-N/A}$, do not adjust the recommendation.
2. If the amount of $\text{NO}_3\text{-N}$ in the 2- to 4-foot depth is more than 30 pounds $\text{NO}_3\text{-N/A}$, reduce the N recommendation by 80 percent of the amount greater than 30 pounds per acre (lb/A). For example, if there are 50 pounds $\text{NO}_3\text{N/A}$ in the 2- to 4-foot depth, reduce the N recommendation by 16 pounds N/A (80 percent of 50 pounds N/A less 30 pounds N/A, or 20 pounds).

Phosphorus and Potassium

The phosphorus (P) and potassium (K) recommended in these tables is the amount to be applied as a broadcast application. Since banded fertilizer generally is used more efficiently in the year of application, the amount of P_2O_5 and K_2O in the tables can be reduced by one-third when banding. Data from field trials in drier or cooler years indicate that small grains, corn and canola will respond to seed-placed or side-banded P fertilizer, even on soils testing medium to high in phosphorus.

Some crops are very sensitive to fertilizer salt injury. No fertilizer is recommended with the seed for these crops in 15-inch rows or wider. Fertilizer-sensitive crops include all legumes, such as soybean, pea, dry bean and others. Consult individual soil fertility publications for each crop for more information. For information regarding fertilizer rate limits with the seed in small grains, consult NDSU Extension publication EB-62.

Under no-till, and especially ridge-till systems, corn and soybean have responded to banded K even when soil test levels for K are high.

Broadcast recommendations of P or K for low and very low testing soils include buildup P and K rates. When rates are reduced, soil test levels are not increased through time. A long-term P and K strategy should include buildup to medium soil test levels at some future date. Near maximum yield potential is achieved only when these soil test levels are reached. Application of less than maintenance rates will result in a decline in P and K levels through time and an accompanying decline in the productivity of most crops.

Sulfur

Sulfur (S) deficiency is most likely to occur on sandy soils throughout the state and on well-drained, medium-textured soils. It appears most often on higher landscape positions with a thin-surface organic-matter layer ("A" horizon) and coarse soil texture (loam to sand and gravel). Our current S soil test characterizes the S status of the soil very poorly. Having the test underestimate or overestimate the available S in soil is common for a variety of reasons. A better plan often is to note the texture, organic-matter content, landscape position and rainfall in the past year as a predictor of S need than to soil test.

If a soil test is nonetheless desired, since sulfate-S ($\text{SO}_4\text{-S}$) is quite soluble, the top 2 feet of soil should be sampled, using a procedure similar to the one recommended for N and chloride (SF-880). If the amount of $\text{SO}_4\text{-S}$ is less than 16 lb/A in the top 2 feet, certain crops may respond to S fertilizer. Canola is especially responsive S. In canola, a high composite $\text{SO}_4\text{-S}$ soil test result would result in a recommendation of 10 to 15 pounds of S/acre, while with a low to medium $\text{SO}_4\text{-S}$ test result, the recommended rates would be 20 to 30 pounds of S/acre. Sulfur is recommended for canola on high testing soils because of the variability of soil S levels, the poor relationship of S soil analysis with S responses and the tremendous effect that S deficiency can have on this crop. Sulfur is not recommended on high testing soils for other crops.

Chloride

The chloride (Cl) soil test is calibrated only for small grains, although a few responses also have been seen in corn within the U.S. In general, responses to Cl in small grains have been in the range of 1 to 6 bu/A on responsive sites. The Cl recommendation is determined by subtracting the amount of Cl found in the top 2 feet of soil from 40 lb/A, although most of the yield response comes generally from the first 10 to 15 lb/A of Cl applied. The most commercially available and cheapest source of Cl fertilizer is 0-0-60 (Potassium chloride, muriate of potash) which contains approximately 50 percent Cl.

Other Nutrients

The DTPA analysis is used to test soils for plant-available zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu). Calibration data are available only for Zn on Zn-sensitive crops, such as corn, soybean, sorghum, potato, flax and edible bean, and Cu on wheat/durum and barley. Micronutrient requirements are crop-specific. Additional crops would not be expected to respond to Zn or Cu if not listed above.

Zinc

When corn, soybean, sorghum, potato, flax or edible bean are to be grown on a field testing low to very low in Zn, the recommendation is to apply 10 lb/A of Zn as zinc sulfate in a broadcast application, or one-third of that rate as a band. Zinc is especially required in these crops if high levels of broadcast P or a starter P fertilizer is applied when soil Zn levels are low. Water solubility is important in efficient dispersion and uptake. Also, the application is more likely to achieve a first-year response to zinc sulfate if the fine granular formulation of the product were used instead of the MAP or DAP-sized granules usually available.

A fine granular application should be made using a fine-granular applicator similar to those used in the past to apply granular herbicide formulations. The distribution of large granules may not be adequate to supply all plants with Zn. A broadcast application of zinc sulfate should correct a Zn deficiency for four to five years.

Zinc chelates at suggested manufacturer rates also may be used, but are relatively expensive per pound of plant food and offer no residual soil buildup. Banded chelates at 1 pint to 2 quarts/A often are used at planting. Foliar applications of zinc chelate and other soluble Zn fertilizers at low rates also are effective for correction of deficiencies for a single season. No Zn is recommended on fields testing medium or above or on fields testing very low, low or medium if the crop to be grown is not a Zn-sensitive crop.

Iron

In general, the supply of soluble Fe to plants from soil is related to the soil carbonate level, which is important when soil pH is more than 7. If carbonates are present, soil wetness, cold soils, excessive tillage and high soluble-salt levels influence the presence and severity of chlorosis. Most of our crops are not sensitive to low available iron and are adapted to regional conditions.

However, iron chlorosis has been seen in flax, field pea and dry bean and is a particularly serious problem in soybean.

Seed treatment with FeEDDHA provides an early-season green-up, but yield responses have been small. Foliar applications have been inconsistent in increasing yield and multiple applications may be necessary. If treatments are made, they should be conducted early in the crop year. Late treatment of the crop will be much less effective. The best solution on fields where iron chlorosis occurs is to plant varieties that are more resistant to this problem. NDSU rates about 200 soybean varieties each year for chlorosis resistance. The most recent data can be found at www.soilsci.ndsu.nodak.edu/yellowsoybeans and www.yellowsoybeans.com.

Manganese

Few documented responses to manganese in North Dakota are available. Therefore, a recommendation is not generally made for any soil test level.

Copper

In a recent study in North Dakota, yield increases due to soil-applied copper were documented; however, the responses were on low organic-matter, loamy sand soils with low (less than 0.3 ppm) copper levels. A number of companion trials on similar soils resulted in no yield increase. At best, copper should be applied only to low organic-matter, sandy soils with low copper levels, but expect a success rate of about 15 percent. Copper is expensive and its use should be based on weighing the productivity of responsive soils with low return of benefits if copper were applied.

Fertilization Recommendation Tables for Crops Commonly Grown in North Dakota

The following tables can be used for the yield potentials shown.

For other yield potentials, use the equations at the bottom of each table.

The abbreviations used in the tables are as follows:

- YP = yield potential
- STN = soil test nitrogen
- STP = soil test phosphorus
- STK = soil test potassium
- PCC = previous crop credit

Table 1. Soil test calibration levels used in North Dakota.

Nutrient	Name of Test	Categories				
		Very Low	Low	Medium	High	Very High
		ppm extractable				
Phosphorus (P), ppm	Olsen	0-3	4-7	8-11	12-15	16+
Potassium (K), ppm	Ammonium acetate	0-40	41-80	81-129	121-160	161+
Zinc (Zn)*, ppm	DTPA	0-0.25	0.26-0.50	0.51-0.75	0.76-1.00	1.01+
Iron (Fe), ppm	DTPA	no categories				
Copper (Cu)**	DTPA	0-0.10	0.10-0.20	0.20-0.30	0.30+	
Manganese (Mn)***, ppm	DTPA	no categories				
Boron, ppm	Hot water	no categories				
		lbs/acre extractable				
Nitrogen (N)	H ₂ O Extract	Calibration of nitrogen is dependent on yield potential and crop				
Sulfur (S), lb/a-2 feet	H ₂ O Extract	0-9	10-19	20-29	30-39	40+
Chloride (Cl), lb/a-2 feet****	H ₂ O Extract	0-10	10-20	20-30	30-40	40+

* This calibration is only for sensitive crops, such as corn, potato, flax and edible beans.

** This calibration is only for wheat and barley in sandy loam or coarser soils with organic matter less than 2.5 percent. Response to copper is not common. Responses have been found only in 15 percent of medium or lower testing locations.

*** Deficiencies of these nutrients have not been confirmed in North Dakota.

**** This calibration is only for small grain.

The amount of nutrient extracted by a particular soil extractant has little meaning or usefulness until it has been calibrated under field conditions. In North Dakota, we use five soil test calibration categories to give meaning to the soil test results. The categories from very low to very high are defined as follows, **unless explained differently above**:

- **Very Low (VL)** In this category, the probability of getting a response to applied nutrient is greater than 80 percent.
- **Low (L)** Crops growing on fields in this category will respond to applied nutrient 50 percent to 80 percent of the time.
- **Medium (M)** The probability of getting a response to applied nutrient is 20 percent to 50 percent.
- **High (H)** In this category, crops will respond to applied nutrient about 10 percent to 20 percent of the time.
- **Very High (VH)** The probability of getting a response to applied nutrient is less than 10 percent.

Table 2. Alfalfa.

Yield potential ton/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
2	0		34	24	15	6	0	96	66	35	5	0
4	0		67	49	30	12	0	192	132	71	10	0
5	0		84	61	38	15	0	241	165	89	13	0
6	0		101	73	45	17	0	289	197	106	15	0

Alfalfa

Inoculation is necessary with proper rhizobium culture.

Bray-1 P recommendation = (18.57-0.93 STP)YP (Annual rates of P₂O₅ and K₂O)

Olsen P recommendation = (18.57-1.16 STP)YP

Potassium recommendation = (55.71-0.38 STK)YP

Table 3. Barley, feed.

Yield potential bu/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
40	70		28	20	12	4	0	45	31	17	3	0
60	100		43	31	19	7	0	67	47	26	5	0
80	135		57	41	25	9	0	89	62	35	7	0
100	170		71	51	31	11	0	112	78	44	8	0

Barley, feed

Nitrogen recommendation = 1.7 YP-STN-PCC

Bray-1 P recommendation = (0.785-0.039 STP)YP

Olsen P recommendation = (0.785-0.050 STP)YP

Potassium recommendation = (1.2860-0.0085 STK)YP

Table 4a. Barley, malting grade, in cooler, moister climates within North Dakota.

**Barley,
malting grade,
in cooler,
moister
climates within
North Dakota**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
40	60		28	20	12	4	0	45	31	17	3	0
60	90		43	31	19	7	0	67	47	26	5	0
80	120		57	41	25	9	0	89	62	35	7	0
100	150		71	51	31	11	0	112	78	44	8	0

Nitrogen recommendation = 1.5 YP-STN-PCC
 Bray-I P recommendation = (0.785-0.039 STP)YP
 Olsen P recommendation = (0.785-0.050 STP)YP
 Potassium recommendation = 1.2860-0.0085 STK)YP

Early planting is critical for greatest success.
 Planting later than May 15 will require lower N rates.
 Applying potassium chloride (0-0-60) at 15-20 lb K₂O/acre can increase kernel plumpness on well-drained soils if a chloride test is not available.

Table 4b. Barley, malting grade, in warmer, drier climates within North Dakota*.

**Barley,
malting grade,
in warmer, drier
climates within
North Dakota**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
40	48		28	20	12	4	0	45	31	17	3	0
60	72		43	31	19	7	0	67	47	26	5	0
80	96		57	41	25	9	0	89	62	35	7	0
100	120		71	51	31	11	0	112	78	44	8	0

Nitrogen recommendation = 1.2 YP-STN-PCC
 Bray-I P recommendation = (0.785-0.039 STP)YP
 Olsen P recommendation = (0.785-0.050 STP)YP
 Potassium recommendation = (1.2860-0.0085 STK)YP

Early planting is critical for greatest success.
 Planting later than May 15 will require lower N rates.
 Applying potassium chloride (0-0-60) at 15-20 lb K₂O/acre can increase kernel plumpness on well-drained soils if a chloride test is not available.

* This recommendation is most useful for the North Dakota region from north of Williston south, and everything west of the Missouri River. In years with low soil moisture, growers further east may benefit from this formula (see Figure 1).

Table 5. Buckwheat.

Buckwheat

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
25	55		30	22	13	5	0	41	29	18	6	0
30	65*		36	26	16	6	0	49	35	21	7	0
35	75*		42	30	19	7	0	57	41	25	8	0
40	90*		48	35	21	8	0	65	47	28	9	0

Nitrogen recommendation = 2.2 YP - STN - PCC
 Bray-I P recommendation = (1.320-0.066 STP)YP
 Olsen P recommendation = (1.320-0.083 STP)YP
 Potassium recommendation = (1.8600-0.0116 STK)YP

* N fertilizer rates greater than 50 lb/acre can cause lodging in wet years.

Table 6. Canola.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
lb/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
1000	65		33	24	15	6	0	47	34	20	6	0
1500	100		49	36	23	9	0	71	50	30	10	0
2000	130*		65	48	30	13	0	94	67	40	13	0
2300	150		75	55	35	18	0	108	77	46	15	0
2500	150		82	60	38	16	0	118	84	50	16	0
3000	150		98	72	46	18	0	142	100	60	20	0

Canola

Nitrogen recommendation = 0.065 YP-STN-PCC with a 150 lb max limit

Bray-I P recommendation = (0.036-0.0017 STP)YP

Olsen P recommendation = (0.036-0.0022 STP)YP

Potassium recommendation = (0.054-0.00034 STK)YP

* Growers in warmer, drier areas should cap N rates at 120 lb N/a. (see Fig.1).

Note: Canola has a high requirement for sulfur. Application of 20-30 lb/a S is recommended regardless of soil test for this crop. Apply S as sulfate or thiosulfate form.

Table 7. Clover (Alsike, Red, Birdsfoot Trefoil, grass-legume).

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
2	0		36	25	13	2	0	87	60	34	7	0
3	0		54	37	20	3	0	130	90	50	11	0
4	0		72	49	27	4	0	173	120	67	14	0
5	0		90	62	34	6	0	217	150	84	18	0

Clover (Alsike, Red, Birdsfoot Trefoil, grass-legume)

Inoculation is required at seeding with proper rhizobium culture.

Bray-I P recommendation = (20-STP)YP

Olsen P recommendation = (20-1.4 STP)YP

Potassium recommendation = (50.000-0.332 STK)YP

Table 8. Corn, grain and popcorn.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
80*	96		51	37	22	8	0	82	58	35	12	0
100	120		63	46	28	11	0	102	73	44	14	0
150	180		95	69	42	16	0	153	109	65	22	0
200	240		127	92	56	21	0	204	146	87	29	0

Corn, grain and popcorn

Nitrogen recommendation = 1.2 YP-STN-PCC

Bray-I P recommendation = (0.700-0.035 STP)YP

Olsen P recommendation = (0.700-0.044 STP)YP

Potassium recommendation = (1.1660-0.0073 STK)YP

* We suggest that growers not plan for yield potential less than 80 bu/a anywhere in North Dakota due to inefficiency of N uptake under unfavorable soil moisture conditions.

Table 9. Corn, silage.**Corn, silage**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
ton/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
10	105		51	37	23	9	0	83	59	35	11	0
14	145		71	52	32	13	0	116	83	49	15	0
18	185		92	67	41	16	0	149	106	63	20	0
22	230		112	81	50	20	0	183	130	77	24	0

Nitrogen recommendation = 10.4 YP-STN-PCC
 Bray-1 P recommendation = (5.62-0.28 STP)YP
 Olsen P recommendation = (5.62-0.35 STP)YP
 Potassium recommendation = (9.50-0.06 STK)YP

Table 10. Sweet corn.**Sweet corn**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
ton/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
4	70		40	29	17	6	0	78	57	36	15	0
6	110		60	43	26	9	0	116	85	54	23	0
8	145		80	57	35	12	0	155	114	72	30	0
10	180		100	72	44	16	0	194	142	90	38	0

Nitrogen recommendation = 18 YP - STN - PCC
 Bray-1 P recommendation = (11.000-0.533 STP)YP
 Olsen P recommendation = (11.0-0.7 STP)YP
 Potassium recommendation = (22.00-0.13 STK)YP

Table 11. Crambe.**Crambe**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
lb/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
1000	50		33	24	15	6	0	47	34	20	6	0
1500	75		49	36	23	9	0	71	50	30	10	0
2000	100		65	48	30	13	0	94	67	40	13	0
2500	125		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.05 YG - STN - PCC
 Bray-1 P recommendation = (0.0360-0.0018 STP)YG
 Olsen P recommendation = (0.0360-0.0023 STP)YG
 Potassium recommendation = (0.05400-0.00036 STK)YG

Table 12. Dry bean (pinto, navy, other).**Dry bean (pinto, navy, other)**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
lb/acre-2'			lb P ₂ O ₅ /acre					lb K ₂ O/acre				
See below			45	30	20	10	0	50	20	0	0	0

Nitrogen recommendation =
 Irrigated sands 0.05 YP - STN - PCC
 Dryland –
 Inoculated 40 lb N/acre - STN-PCC
 Noninoculated 70 lb N/acre - STN-PCC

Phosphorus and potassium responses are not related to yield potential, but only to soil test levels.

Table 13. Flax

Yield potential bu/a	Soil N plus fertilizer N required lb/acre-2'	Soil Test Potassium, ppm				
		VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
20	60	38	27	16	5	0
30	80	58	41	24	7	0
40	80	77	54	32	10	0
50	80	96	68	40	12	0

Nitrogen recommendation = 3 YP - STN - PCC, with limit of 80 lb/N.

N is limited to 80 lb/a due to the risk of lodging. If environment is favorable for higher yield, higher N release from organic matter will provide the added N in most situations.

Phosphorus application is not necessary for flax. Phosphorus can be applied, but no yield increase should be expected regardless of soil test level.

Potassium recommendation = (2.200-0.014 STK)YP

Flax**Table 14. Forage/hay grasses, established grass, irrigated, new seedings.**

Yield potential ton/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
2	50*		40	26	12	0	0	69	48	27	6	0

Nitrogen recommendation = 25 YP-STN
 Bray-1 P recommendation = 45.0-2.5 STP
 Olsen P recommendation = 45.00-3.45 STP
 Potassium recommendation = 80.00-0.53 STK

* Nitrogen application to native grass stands is discouraged due to selective pressures from less desirable plants with higher N nutrition. Native grass stands sometimes can benefit from P application.

Forage/hay grasses, established grass, irrigated, new seedings**Table 15. Millet and canary seed.**

Yield potential lb/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
1500	50		23	16	9	3	0	40	29	18	7	0
2000	70		31	22	13	3	0	53	38	24	10	0
2500	90		38	27	16	4	0	66	48	30	12	0
3000	105		46	32	19	5	0	79	58	36	14	0

Nitrogen recommendation = 0.035 YP-STN-PCC
 Bray-1 P recommendation = (0.0171-0.00085 STP)YP
 Olsen P recommendation = (0.0171-0.00114 STP)YP
 Potassium recommendation = (0.03-0.00018 STK)YP

Millet and canary seed**Table 16. Mustard.**

Yield potential lb/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
1000	65		33	24	15	6	0	47	34	20	6	0
1500	100		49	36	23	9	0	71	50	30	10	0
2000	130		65	48	30	13	0	94	67	40	13	0
2500	150*		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.065 YP-STN-PCC
 Bray-1 P recommendation = (0.036-0.0017 STP)YP
 Olsen P recommendation = (0.036-0.0022 STP)YP
 Potassium recommendation = (0.054-0.00034 STK)YP

* There is a cap of 150 lb N regardless of yield potential.

Mustard

Table 17. Oat.

Oat

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
50	65		29	21	13	5	0	55	38	21	4	0
70	90		41	29	18	7	0	77	53	29	5	0
90	115		52	38	23	8	0	100	69	38	7	0
110	145		64	46	28	10	0	122	84	46	8	0

Nitrogen recommendation = 1.3 YP-STN-PCC
 Bray-1 P recommendation = (0.644-0.032 STP)YP
 Olsen P recommendation = (0.644-0.041 STP)YP
 Potassium recommendation = (1.2777-0.0086 STK)YP

Table 18. Pea, field, lentil and chickpea (garbanzo bean).

Pea, field, lentil and chickpea (garbanzo bean)

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
lb/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
1400	20		22	15	9	3	0	37	27	17	7	0
1800	20		28	20	12	4	0	48	35	22	9	0
2200	20		34	24	15	5	0	58	42	26	11	0
2600	20		40	29	17	6	0	69	50	31	13	0

Bray-1 P recommendation = (0.0171-0.00085 STP)YP
 Olsen P recommendation = (0.0171-0.0011 STP)YP
 Potassium recommendation = (0.03-0.00018 STK)YP
 Inoculation is necessary with proper rhizobium culture

Table 19. Potato.

Potato

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
cwt/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
200	80		90	63	35	8	0	147	102	56	10	0
300	120		135	94	53	12	0	221	152	84	16	0
400	160		180	125	71	16	0	294	203	112	21	0
500	200		225	157	89	21	0	368	254	140	26	0

Nitrogen recommendation = 0.4 YP-STN-PCC
 Bray-1 P recommendation = (0.5-0.024 STP)YP
 Under irrigation, N application should be split to reduce nitrate leaching risk. Supplemental N should be directed

Table 20. Safflower.

Safflower

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
lb/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
800	40		20	14	9	3	0	34	24	14	5	0
1200	60		29	21	13	5	0	50	36	22	7	0
1600	80		39	28	17	6	0	67	48	29	10	0
2000	100		49	35	22	8	0	84	60	36	12	0

Nitrogen recommendation = 0.05 YP-STN-PCC
 Bray-1 P recommendation = (0.027-0.0014 STP)YP
 Olsen P recommendation = (0.027-0.0017 STP)YP
 Potassium recommendation = (0.048-0.0003 STK)YP
 Safflower will extract N from depths of more than 4 feet. Excessive N will delay maturity and lower oil content.

Table 21. Sorghum, forage and sudangrass.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
ton/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
3	75		30	21	13	5	0	111	75	39	3	0
5	125		50	36	22	8	0	185	125	65	5	0
7	175		70	50	30	11	0	259	175	91	7	0
9	225		90	64	39	14	0	333	225	117	9	0

Nitrogen recommendation = 25 YP-STN-PCC
 Bray-I P recommendation = (11.000-0.533 STP)YP
 Olsen P recommendation = (11.0-0.7 STP)YP
 Potassium recommendation = (43.0-0.3 STK)YP

Sorghum, forage and sudangrass**Table 22. Sorghum, grain.**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
60	66		36	26	17	7	0	46	32	18	4	0
80	88		48	35	22	9	0	61	42	24	5	0
100	110		60	44	28	11	0	76	53	30	6	0
120	132		72	53	33	14	0	91	63	35	8	0

Nitrogen recommendation = 1.1 YP-STN-PCC
 Bray-I P recommendation = (0.666-0.033 STP)YP
 Olsen P recommendation = (0.666-0.041 STP)YP
 Potassium recommendation = (0.875-0.0058 STK)YP

Sorghum, grain**Table 23. Soybean.**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
bu/a	lb/acre-2'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
30	0		40	2	10	0	0	55	33	11	0	0
40	0		54	31	10	0	0	73	44	15	0	0
50	0		67	39	11	0	0	92	55	19	0	0
60	0		80	47	13	0	0	110	66	22	0	0

Bray-I P recommendation = (1.55-0.10 STP)YP
 Olsen P recommendation = (1.55-0.14 STP)YP
 Potassium recommendation = (2.2000-0.0183 STK)YP
 Inoculation, or rotation within four years of a well-nodulated soybean crop is necessary.

Soybean**Table 24. Sugar beet.**

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL	L	M	H	VH	VL	L	M	H	VH
			0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21+ 16+	0-40	41-80	81-120	121-160	161+
ton/a	lb/acre-4'		lb P ₂ O ₅ /acre					lb K ₂ O/acre				
20	130		80	58	36	15	0	110	77	43	9	0

Bray-I P recommendation = (4.38-0.22 STP)YP
 Olsen P recommendation = (4.38-0.27 STP)YP
 Potassium recommendation = (6.350-0.042 STK)YP

A minimum of 65 lb N should be in the 0-2 foot depth.
 Soil N plus fertilizer N required with a 0-2 foot core only is 100 lb/acre.

Sugar beet

Sunflower

Table 25. Sunflower.

Yield potential lb/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
			lb P ₂ O ₅ /acre					lb K ₂ O/acre				
1000	50		20	15	9	4	0	36	25	14	3	0
1500	75		31	22	14	5	0	53	37	21	5	0
2000	100		41	30	18	7	0	71	50	28	6	0
2500	125		51	37	23	9	0	89	62	35	8	0

Nitrogen recommendation = 0.05 YP-STN-PCC
 Bray-1 P recommendation = (0.0225-0.0011 STP)YP
 Olsen P recommendation = (0.0225-0.0014 STP)YP
 Potassium recommendation = (0.041-0.00027 STK)YP

Wheat, spring, durum, winter and rye

Table 26. Wheat, spring, durum, winter and rye.

Yield potential bu/a	Soil N plus fertilizer N required lb/acre-2'	Bray-1 Olsen	Soil Test Phosphorus, ppm					Soil Test Potassium, ppm				
			VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
			lb P ₂ O ₅ /acre					lb K ₂ O/acre				
20	50		19	17	9	3	0	47	34	20	7	0
40	100		39	35	17	7	0	95	68	40	13	0
60	150		58	52	26	10	0	142	101	60	20	0
80	200		78	69	35	13	0	190	135	80	26	0

Nitrogen recommendation = 2.5 YP-STN-PCC
 Bray-1 P recommendation = (1.071-0.054 STP)YP
 Olsen P recommendation = (1.071-0.067 STP)YP
 Potassium recommendation = (2.71-0.017 STK)YP

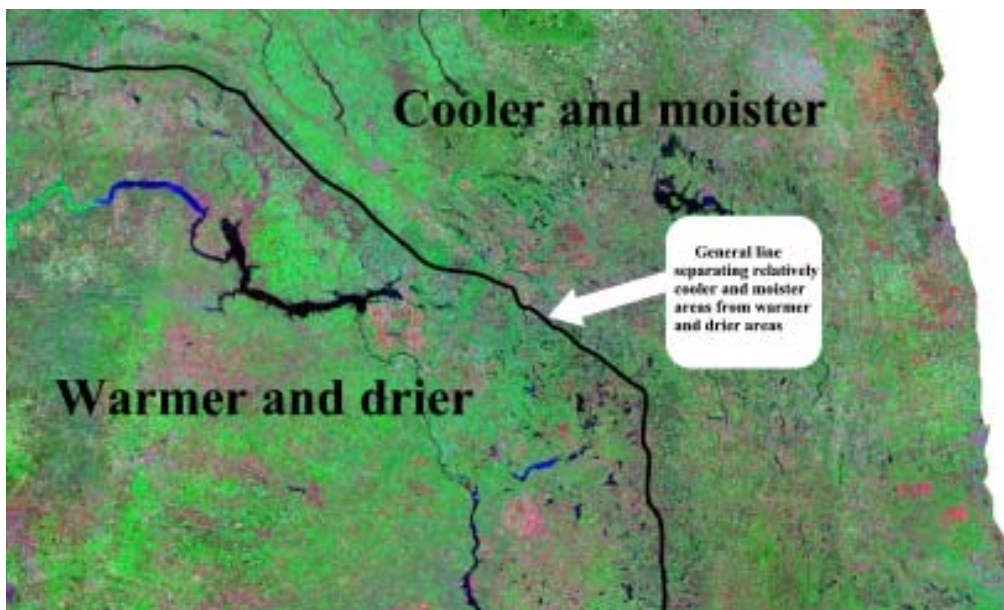


Figure 1.

General climatic delineation between cooler and moister areas in North Dakota, compared with warmer and drier areas. In a given year, the line separating the two regions may move considerably east or west.

For use with Tables 4a, 4b and 6.

(Image courtesy of NASA, Angela King – image compiler, and Hobart King/ Geology.com – publisher).

This publication may be copied for noncommercial, educational purposes in its entirety with no changes. Requests to use any portion of the document (including text, graphics or photos) should be sent to permission@ndsuxent.nodak.edu. Include exactly what is requested for use and how it will be used.

For more information on this and other topics, see: www.ag.ndsu.edu



County Commissions, North Dakota State University and U.S. Department of Agriculture cooperating. Duane Hauck, Director, Fargo, North Dakota. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. We offer our programs and facilities to all persons regardless of race, color, national origin, religion, gender, disability, age, veteran's status or sexual orientation; and are an equal opportunity institution. This publication will be made available in alternative formats for people with disabilities upon request, (701) 231-7881.