SF882 (Revised)

North Dakota Fertilizer Recommendation Tables and Equations

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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. **This publication contains changes from previous publications. Please dispose of older editions.** Changes to tables were based on new or re-evaluated data.

The major changes are:

- Separation of spring wheat and durum recommendations from winter wheat and rye
- Spring wheat and durum nitrogen (N) recommendations
- Simplification of winter wheat and rye N recommendations
- Wheat and rye potassium (K) 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 potential be based on a historical yield tendency 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 in organic matter and have a higher seasonal moisture content. The exception to this would be saline areas that are commonly 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 most crops except some legumes are based on the amount of nitrate-N (NO_3-N) in the top 2 feet of soil and the yield potential. Nitrogen fertilizer recommendations are not adjusted based on method of placement, but they are adjusted for previous crop and depth of sampling. To determine the amount of recommended fertilizer N, subtract the amount of NO_3N 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. Spring wheat and durum recommendations include economic components.

For example:

Your NDSU soil test shows 55 pounds of NO_3N are present in the soil to 2 feet. Your yield history 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 nitrogen per acre (N/A). The difference between 100 pounds and 55 pounds (the soil test) is 45 pounds of N. Therefore, the N recommendation is 45 lb N/acre.

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Adjusting N Recommendations

In a preplant NO_3N 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 (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 indicates that some crops (soybeans) may accelerate the normal N mineralization rate from organic matter. Nitrogen availability is greater after crops with a 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
34 plants/sq. ft.	100 lb N/acre
12 plants/sq. ft.	50 lb N/acre
<1 plant /sq. ft.	0 lb N/acre
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 NO_3-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. Sugar beet N recommendations for 2-foot and 4-foot samplings are provided in Table 25. If deeper sampling is conducted to refine recommendations or screen for problems in malting barley, sunflower or safflower, the following adjustments would apply:

If the amount of NO_3-N in the 2- to 4-foot depth is less than 30 lb NO_3-N/A, do not adjust the recommendation.

If the amount of NO_3-N in the 2- to 4-foot depth is more than 30 lb NO_3-N/A, reduce the N recommendation by 80 percent of the amount greater than 30 lb/A. For example, if 50 lb NO_3-N/A are in the 2- to 4-foot depth, reduce the N recommendation by 16 lb N/A (80 percent of 50 lb N/A less 30 lb 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 indicates 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 and dry bean. 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. It's available online at *www.ag.ndsu.edu/pubs/plantsci/soilfert/eb62w.htm*.

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 most likely will occur on sandy soils throughout the state and on welldrained, mediumtextured 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. The test commonly underestimates or overestimates the available S in soil for a variety of reasons. Noting the texture, organic matter content, landscape position and rainfall in the past year often is a better predictor of S need than soil testing.

If a soil test is desired nonetheless, since sulfate-S (SO_4-S) is quite soluble, the top 2 feet of soil should be sampled, similar to the procedure recommended for N and chloride (SF-880).

Canola is especially responsive S. In canola, a high composite SO4-S soil test result would result in a recommendation of 10 to 15 lb S/acre, while with a low to medium SO_4-S test result, the recommended rates would be 20 to 30 lb 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 (diethylenetriaminepentaacetic acid) 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, potato, flax and edible bean, and for 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, potato, flax or edible beans are to be grown on a field testing low to very low in Zn, the recommendation is to apply 10 lb/acre 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 crop is more likely to achieve a first-year response to zinc sulfate if the fine granular formulation of the product is used instead of the MAP (mono-ammonium phosphate) or DAP (diammonium phosphate)-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 are also 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 iron (Fe) to plants from soil is related to the soil carbonate level, which is important when the soil pH is over 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 (iron-ethylenediaminedi(o-hydroxyphenylacetic) acid) provides an early season greenup, but yield responses have been small. Foliar applications have been inconsistent in increasing yield, and multiple applications may be necessary. The best Fe amendment treatment has been the application of recommended rates of FeEDDHA in furrows at seeding. 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.*

Manganese

No field responses to manganese in North Dakota have been documented. Therefore, a recommendation is not made for any soil test level.

Copper

Yield increases due to soil-applied copper were documented in North Dakota; however, the responses were on low organic matter, loamy sand soils with low (less than 0.3 parts per million) 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 the 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.

		Categories				
Nutrient	**Name of Test**	**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)	H2O Extract	*see tables to follow*				
Sulfur (S), lb/a-2 feet	H2O Extract	0-9	10-19	20-29	30-39	40+
Chloride (Cl), lb/a-2 feet****	H2O 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%. Response to copper is not common. Responses have been found only in 15% 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 to 80 percent of the time.
- **Medium (M)** ..... The probability of getting a response to applied nutrient is 20 to 50 percent.
- **High (H)** ..... In this category, crops will respond to applied nutrient about 10 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.

Alfalfa

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
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

Inoculation is necessary with proper rhizobium culture.
Bray-I P recommendation = (18.57-0.93 STP)YP
Olsen P recommendation = (18.57-1.16 STP)YP
Potassium recommendation = (55.71-0.38 STK)YP

(Annual rates of P_2O_5 and K_2O)

Table 3. Barley, feed.

Barley, feed

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
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

Nitrogen recommendation = 1.7 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

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 VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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 K_2O/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 VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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 K_2O/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 VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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.

Canola

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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

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

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

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

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

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

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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

Bray-I P recommendation = (20-STP)YP
Olsen P recommendation = (20-1.4 STP)YP
Potassium recommendation = (50.000-0.332 STK)YP

Inoculation is required at seeding with proper rhizobium culture.

Table 8. Corn, grain and popcorn.

Corn, grain and popcorn

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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

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 VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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-I 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

Sweet corn

Table 10. Sweet corn.

Soil N plus Yield potential	fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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-I 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

Crambe

Table 11. Crambe.

Yield goal	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	Lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	50		33	24	15	6	0	47	34	20	6	0
1,500	75		49	36	23	9	0	71	50	30	10	0
2,000	100		65	48	30	13	0	94	67	40	13	0
2,500	125		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.05 YG - STN - PCC
Bray-I 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

Dry bean (pinto, navy, other)

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

Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/acre-2'		lb P_2O_5/acre					lb K_2O/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

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

Table 13. Flax

Flax

Yield potential	Soil N plus fertilizer N required	Soil Test Potassium, ppm				
		VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'	K_2O, lb/acre				
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

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

Forage/hay grasses, established grass, irrigated, new seedings

Yield potential	Soil N plus fertilizer N required	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+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
2	50*		40	26	12	0	0	69	48	27	6	0

Nitrogen recommendation = 25 YP-STN
Bray-I 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.

Table 15. Millet and canary seed.

Millet and canary seed

Yield potential	Soil N plus fertilizer N required	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/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
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-I 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

Mustard

Table 16. Mustard.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	65		33	24	15	6	0	47	34	20	6	0
1,500	100		49	36	23	9	0	71	50	30	10	0
2,000	130		65	48	30	13	0	94	67	40	13	0
2,500	150*		82	60	38	16	0	118	84	50	16	0

Nitrogen recommendation = 0.065 YP-STN-PCC
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

NonInoculated 70 lb N/acre – STN-PCC

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

Oat

Table 17. Oat.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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-I 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

Pea, field, lentil and chickpea (garbanzo bean)

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

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm: VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm: VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,400	20		22	15	9	3	0	37	27	17	7	0
1,800	20		28	20	12	4	0	48	35	22	9	0
2,200	20		34	24	15	5	0	58	42	26	11	0
2,600	20		40	29	17	6	0	69	50	31	13	0

Bray-I 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.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
cwt/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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-I P recommendation = (0.5-0.024 STP)YP
Olsen P recommendation = (0.5-0.034 STP)YP
Potassium recommendation = (0.85-0.0057 STK)YP

Under irrigation, N application should be split to reduce nitrate leaching risk. Supplemental N should be directed through the use of petiole/sap testing.

Table 20. Rye.

Nitrogen rates

Areas of **low** productivity (yields below 40 bu/acre) ..... Total available N = 100 lb/acre
Areas of **medium** productivity (yields 40 to 60 bu/acre) ..... Total available N = 150 lb/acre
Areas of **high** productivity (yields greater than 60 bu/acre ..... Total available N = 200 lb/acre

(Total available N = soil test nitrate 2 feet + previous crop credit + fertilizer N)

Phosphorus

Low productivity – apply 25 lb P_2O_5/acre at seeding with the seed up to a soil test of 15 ppm
Medium and **high** productivity – apply 40 lb P_2O_5 at seeding with the seed up to a soil test of 15 ppm.

Potassium

All productive ranges – apply 50 lb/acre 0-0-60 (30 lb/acre K_2O) if soil test K is less than 100 ppm.

Table 21. Safflower.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
800	40		20	14	9	3	0	34	24	14	5	0
1,200	60		29	21	13	5	0	50	36	22	7	0
1,600	80		39	28	17	6	0	67	48	29	10	0
2,000	100		49	35	22	8	0	84	60	36	12	0

Nitrogen recommendation = 0.05 YP-STN-PCC
Bray-I 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.

Sorghum, forage and sudangrass

Table 22. Sorghum, forage and sudangrass.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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, grain

Table 23. Sorghum, grain.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/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

Soybean

Table 24. Soybean.

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
bu/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
30	0		40	23	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.

Table 25. Sugar beet.

Sugar beet

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
ton/a	lb/acre-4'		lb P_2O_5/acre					lb K_2O/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- to 2-foot depth. Soil N plus fertilizer N required with a 0- to 2-foot core only is 100 lb/acre.

Table 26. Sunflower.

Sunflower

Yield potential	Soil N plus fertilizer N required	Bray-1 Olsen	Soil Test Phosphorus, ppm VL 0-5 0-3	L 6-10 4-7	M 11-15 8-11	H 16-20 12-15	VH 21+ 16+	Soil Test Potassium, ppm VL 0-40	L 41-80	M 81-120	H 121-160	VH 161+
lb/a	lb/acre-2'		lb P_2O_5/acre					lb K_2O/acre				
1,000	50		20	15	9	4	0	36	25	14	3	0
1,500	75		31	22	14	5	0	53	37	21	5	0
2,000	100		41	30	18	7	0	71	50	28	6	0
2,500	125		51	37	23	9	0	89	62	35	8	0

Nitrogen recommendation = 0.05 YP-STN-PCC
Bray-I 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

Tables 27-1 through 27-9. Spring Wheat and Durum Nitrogen Recommendations

Spring Wheat and Durum (continued on pages 14-15)

To determine recommended N rate:

1. Find the region of the farm and look up the gross optimal available-N from the appropriate region/productivity table (Tables 27-1 through 27-9).
2. Subtract the soil test nitrate-N from the 0- to 2-foot depth.
3. Subtract any previous crop N credits.
4. Consider whether the field has been in a no-till or one-pass tillage system.
   - If the field has been in no-till less than five continuous years, add 20 lb N/acre.
   - If the field has been in no-till five or more continuous years, subtract 50 lb N/acre.
5. Make an organic-matter adjustment for soils with greater than 5.9 percent organic matter.
   - For each full percent of organic matter greater than 5 percent, subtract 50 lb N/acre.

Final N rate may be adjusted plus or minus 30 lb N/acre due to host of factors, including varietal protein traits, soil that tend to favor denitrification, excessive straw from the previous year or less than ideal application methods.

Within each region, the productivity is defined. Productivity category definitions:

- **Langdon Region**
  Low = less than 40 bu/acre
  Medium = 41 to 60 bu/acre
  High = greater than 60 bu/acre
- **Eastern Region**
  Low = less than 40 bu/acre
  Medium = 41 to 60 bu/acre
  High = greater than 60 bu/acre
- **Western Region**
  Low = less than 30 bu/acre
  Medium = 31 to 50 bu/acre
  High = greater than 50 bu/acre

Table 27-1.
Langdon Region Low Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	100	90	80	70	60	50	40	30	20
$4	110	100	90	80	70	60	50	40	30
$5	120	110	100	90	80	70	60	50	40
$6	120	115	110	100	90	80	75	65	60
$7	120	115	110	100	95	90	80	75	70
$8	120	115	110	105	95	90	85	80	75
$9	120	115	110	105	100	95	90	85	80
$10	120	115	110	110	105	100	95	90	85

Table 27-2.
Langdon Region Medium Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	130	125	120	115	110	100	80	50	20
$4	135	130	125	120	115	100	90	80	70
$5	140	135	130	125	120	115	100	90	80
$6	140	135	130	125	120	115	105	95	85
$7	140	135	130	125	120	115	110	100	85
$8	140	135	130	130	125	120	115	105	85
$9	140	135	135	130	125	120	115	110	95
$10	140	135	135	130	125	120	115	110	100

Table 27-3.
Langdon Region High Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	160	145	130	125	110	100	90	75	40
$4	160	150	140	130	120	110	100	90	80
$5	160	155	150	140	130	120	115	105	100
$6	160	155	150	140	135	125	120	116	110
$7	160	155	150	145	135	130	125	120	115
$8	160	155	150	145	140	135	130	125	120
$9	160	155	150	145	140	135	130	130	125
$10	160	155	150	145	140	140	135	135	130

Table 27-4.
Eastern North Dakota Low Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	100	90	75	60	0	0	0	0	0
$4	120	100	90	75	40	20	0	0	0
$5	160	140	120	100	90	75	40	20	0
$6	160	145	130	115	100	85	70	20	0
$7	160	150	135	120	105	90	75	40	20
$8	160	150	140	125	110	95	80	65	50
$9	160	150	145	125	115	105	95	85	75
$10	160	155	150	145	140	130	125	115	100

Table 27-5.
Eastern North Dakota Medium Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	175	160	140	110	20	0	0	0	0
$4	180	165	145	125	100	40	0	0	0
$5	190	180	165	150	135	125	100	75	0
$6	200	190	185	175	160	150	100	75	20
$7	200	190	185	180	170	155	140	125	115
$8	200	190	185	180	175	160	145	130	120
$9	200	195	190	185	175	165	155	140	125
$10	200	200	195	190	180	170	160	145	130

Table 27-6.
Eastern North Dakota High Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	250	230	210	190	140	0	0	0	0
$4	250	250	250	240	175	160	100	0	0
$5	250	250	250	250	225	200	150	125	0
$6	250	250	250	250	240	225	160	150	150
$7	250	250	250	250	250	250	210	180	115
$8	250	250	250	250	250	250	250	225	200
$9	250	250	250	250	250	250	250	250	225
$10	250	250	250	250	250	250	250	250	250

Table 27-7. Western North Dakota Low Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	100	90	80	70	60	0	0	0	0
$4	120	110	100	90	80	65	50	0	0
$5	120	110	100	90	80	70	60	50	0
$6	120	115	110	105	100	95	90	85	80
$7	120	120	115	110	105	100	100	95	90
$8	120	120	115	115	110	105	105	100	100
$9	120	120	120	120	115	110	110	110	110
$10	120	120	120	120	120	120	120	120	120

Table 27-8. Western North Dakota Medium Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	150	150	145	130	115	100	0	0	0
$4	150	150	150	140	125	110	100	0	0
$5	150	150	150	145	130	120	110	100	25
$6	150	150	150	150	140	130	120	110	100
$7	150	150	150	150	150	140	140	130	120
$8	150	150	150	150	150	150	150	145	140
$9	150	150	150	150	150	150	150	150	150
$10	150	150	150	150	150	150	150	150	150

Table 27-9. Western North Dakota High Productivity.

	Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	Gross Optimal N								
$3	200	190	175	150	135	120	100	0	0
$4	200	190	180	160	150	140	130	120	0
$5	200	195	185	180	175	165	155	140	130
$6	200	200	190	185	180	170	160	150	140
$7	200	200	195	190	185	175	165	155	150
$8	200	200	195	195	190	185	175	170	165
$9	200	200	200	200	190	190	190	190	180
$10	200	200	200	200	200	200	200	200	200

Table 27-10. Broadcast fertilizer phosphate recommendations for North Dakota for spring wheat and durum based on soil test (Olsen sodium bicarbonate) and yield potential.

	Soil Test Phosphorus, ppm				
Yield Potential	VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+
bu/acre	Pounds P_2O_5/acre				
40	39	28	17	15	15*
60	59	42	26	15	15
80	78	56	35	15	15
100	98	70	43	17	15

Olsen P recommendations = (1.071-0.067STP)YP, where STP is soil test P and YP is yield potential.

* Wheat seeding always should include a small amount of starter fertilizer in a band regardless of soil test. If starter fertilizer banding is not used, rates in H and VH categories should be zero.

Potassium recommendations for spring wheat and durum –

- Soil test K > 100 ppm, no additional K required. KCl (0-0-60-50Cl) may be applied if Cl levels are low.
- Soil test K 100 ppm or less, apply 50 lb/acre KCl (30 lb/acre K_2O)

Table 28. Winter wheat.

Nitrogen rates –

Areas of **low** productivity
(yields below 40 bu/acre) ..... Total available N = 100 lb/acre

Areas of **medium** productivity
(yields 40 to 60 bu/acre) ..... Total available N = 150 lb/acre

Areas of **high** productivity
(yields greater than 60 bu/acre ..... Total available N = 200 lb/acre

(Total available N = soil test nitrate 2 feet + previous crop credit + fertilizer N)

Also, if growing winter wheat in Langdon Region (see Figure 2), subtract 40 lb N/acre.

Phosphorus rates –

	Soil Test Phosphorus, ppm				
Productivity level	VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+
bu/acre	Pounds P_2O_5/acre				
<40	39	28	17	15	15*
40-70	60	40	25	15	15
>70	80	60	40	15	15

* Wheat seeding always should include a small amount of starter fertilizer in a band regardless of soil test. If starter fertilizer banding is not used, rates in H and VH categories should be zero.

Potassium rates –

- Soil test K > 100 ppm, no additional K required. (KCl (0-0-60-50Cl) may be applied if Cl levels are low.)
- Soil test K 100 ppm or less, apply 50 lb/acre KCl (30 lb/acre K_2O)

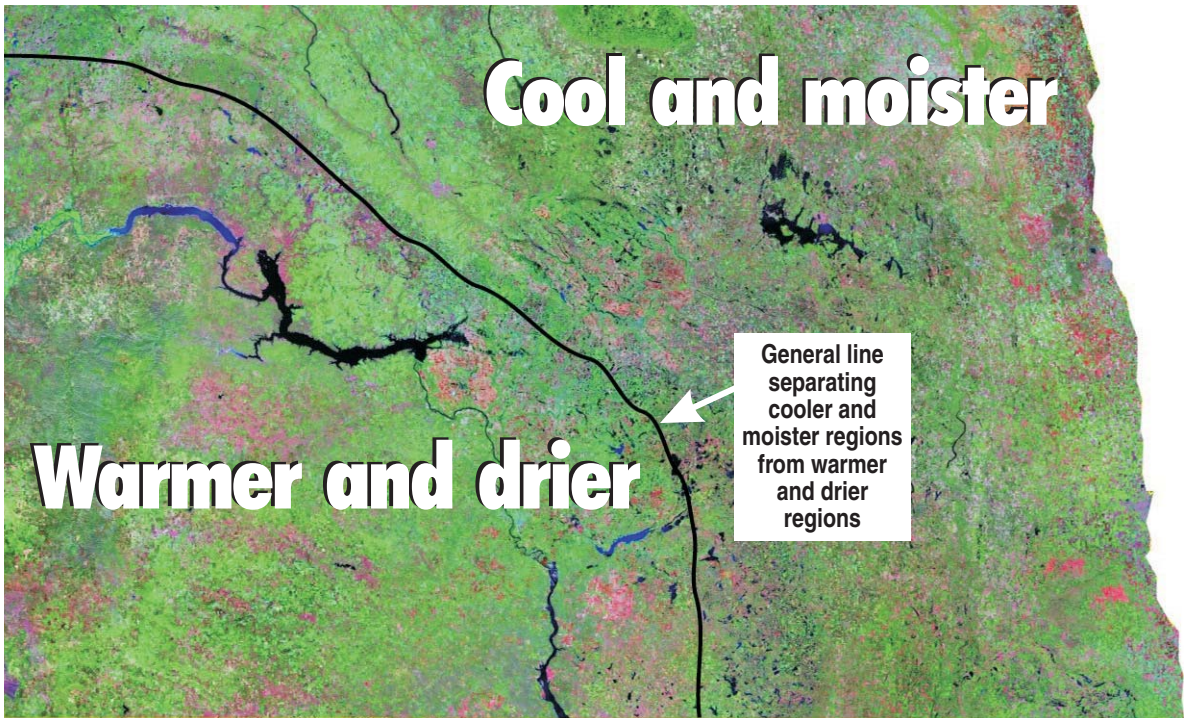

Figure 1.

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).

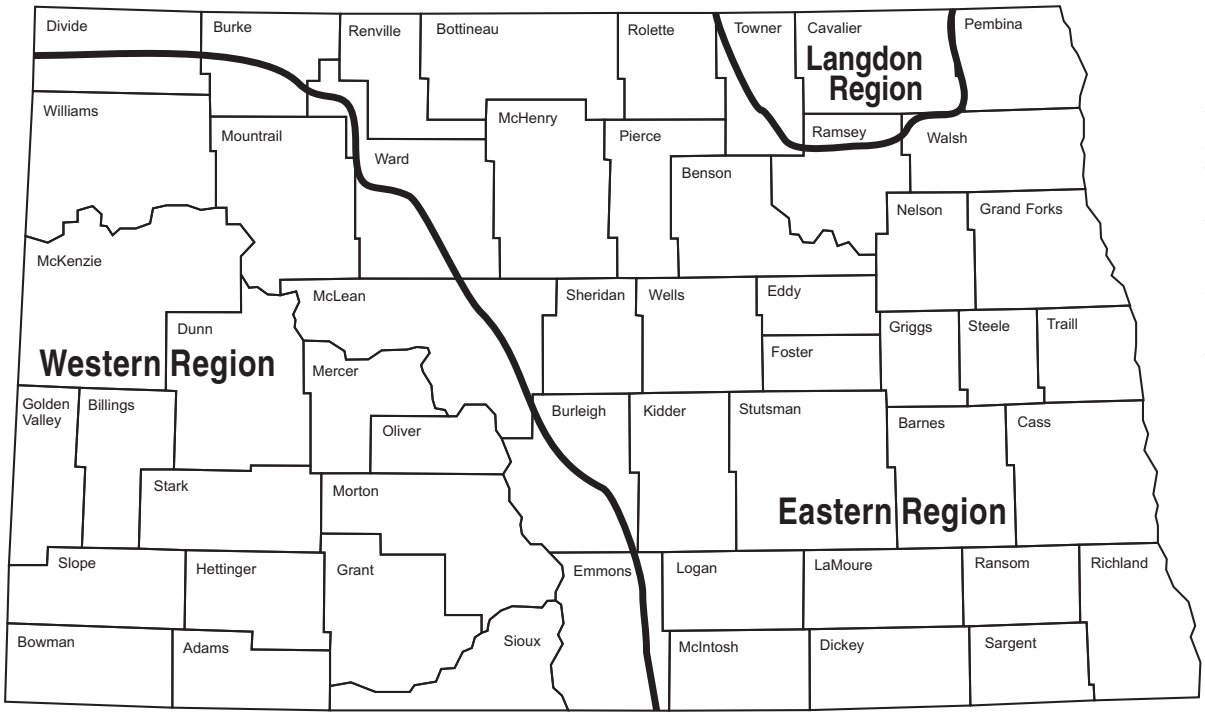

Figure 2.

Agri-climatology regions for use in Tables 27-1 through 27-9 for spring wheat and durum N recommendations, and Table 28 for winter wheat considerations.

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

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