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Summary of Soil Fertility Levels for North Dakota, 1991-2001

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The data summarized in this publication are compiled from soil test analysis conducted at the North Dakota State University Soil Laboratory between 1991 and 2001.

Procedures Used By the Soil Testing Lab at NDSU

Soil testing is widely accepted as a practical guide for evaluating the fertility status of soils. Properly conducted soil tests can be used to make fertilizer recommendations to correct deficiencies, maintain soil nutrient levels for sustained high production or reveal environmentally harmful amounts. Soil test summaries show change in soil nutrient levels through time and help increase awareness of the principal soil fertility problems in a region. Soil test summaries should not be used as a guide to fertilizing individual fields.

NDSU began offering soil testing services to farmers in the fall of 1953. Tests introduced at that time were extractable phosphorus by the $NaHCO_3$ (sodium bicarbonate) procedure, pH (alkalinity or acidity) in a water suspension and electrical conductivity in a 1:1 soil-to-water suspension as a measure of total soluble salts. These tests were offered from 1953 to 1968.

Since 1968, a number of changes have taken place. In the fall of 1968, a test for nitrate-nitrogen (NO_3-N) from soil cores obtained from the surface 2 feet of soil was introduced. At the same time, potassium (K) extractable by 0.5 M $NaHCO_3$ was offered. In 1974, the lab began using 1 N ammonium acetate as the potassium extractant.

Fertilizer recommendation reports were computerized in 1970. In 1972, the DTPA test for zinc was offered. A few years later, tests for iron, copper and manganese, using the same extractant, were offered. A test for chloride (Cl) in the top 2 feet of soil was added in 1986.

Beginning in 1974, fertilizer recommendations were made based on soil test results and the farmer's yield goal. A farmer-provided yield goal allowed consideration of soil differences among fields, climate and management ability. Previously, recommendations were based only on soil test values and climate.

An organic-matter test (Walkley-Black) was introduced in 1974 to help farmers determine soil-applied herbicide rates. Reagent disposal from the Walkley-Black method (chromium) became an environmental concern and the test was replaced by the loss-of-weight-by-ignition test (LOI) in 1988. A test for sulfate-sulfur (calcium phosphate-extractable) in the top 2 feet of soil first was offered in 1976 due to client demand.

In the fall of 1969, a major change was made in the interpretation of the phosphorus (P) soil test. Previously, interpretation of the phosphorus test had been based on soil pH and extractable phosphorus. With that interpretation, the amount of extractable phosphorus had to be greater at lower pH levels than at higher pH levels for a soil sample to be at the same soil test level. The current interpretation uses only the amount of phosphorus extracted from the soil as an indication of the probability of getting a response to applied fertilizer.

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Soil test procedures used during the aggregation of soil tests compiled in this summary are detailed in the publications edited by Dahnke (1980, 1988). Some of these tests have been modified since 1992, and the interpretations and recommendations certainly have been as well.

Soil Test Summary Data

Soil test results for North Dakota are summarized for eight geographical regions of the state (Figure 1). These are the North Red River Valley (N-RRV), South Red River Valley (S-RRV), Northeast Central (NEC), Southeast Central (SEC), Northwest Central (NWC), Southwest Central (SWC), Northwest (NW) and Southwest (SW). Annual precipitation ranges from about 14 inches per year in the west to more than 20 inches per year in the Red River Valley.

County Average Soil Test Values

Although average soil test values are of little use in making fertilizer recommendations for individual fields, comparisons can be made between individual soil test results and the average soil test in a county or neighboring counties. Change in average county levels with annual climatic and yield variations is also noteworthy.

Number of Samples Tested

The average pH, NO_3-N on cropped and fallowed fields, phosphorus and potassium test results for each county in North Dakota is provided in Table 1. During the 1992-2001 period, state averages for pH remained relatively unchanged from the previous 10-year period. Nitrate-N in cropped and fallow fields declined, as did the soil P and K levels, compared with the previous 10-year period.

During the first 20 years of soil testing in North Dakota, the number of fields tested each year was relatively constant (Table 2). An exception was for 1960 to 1961, when an Extension Service campaign was conducted to promote soil testing. From 1970 to 1980, the number of fields tested at the NDSU lab increased markedly.

Part of the reason for the increase was the establishment of 12 private soil testing laboratories in North Dakota during this period. Reasons for the increased interest in soil testing included a larger selection of available tests, improved interpretations and recommendations, increased cost of fertilizer in relation to crop prices and recommendations based on farmer-supplied yield goals, which takes into consideration management skill and flexibility, soil type, climate and soil test values.

From 1980 to 1990, the number of fields tested by the NDSU lab peaked and then declined slightly as farmers became to rely more on private soil testing laboratories. The number of fields tested by the NDSU lab remained relatively stable during the current reporting period, although a decline was noted between 1998 and 2001. Trends in numbers of fields tested by the NDSU Soil Testing Laboratory between 1953 and 2001 are shown in Figure 2 (page 5).

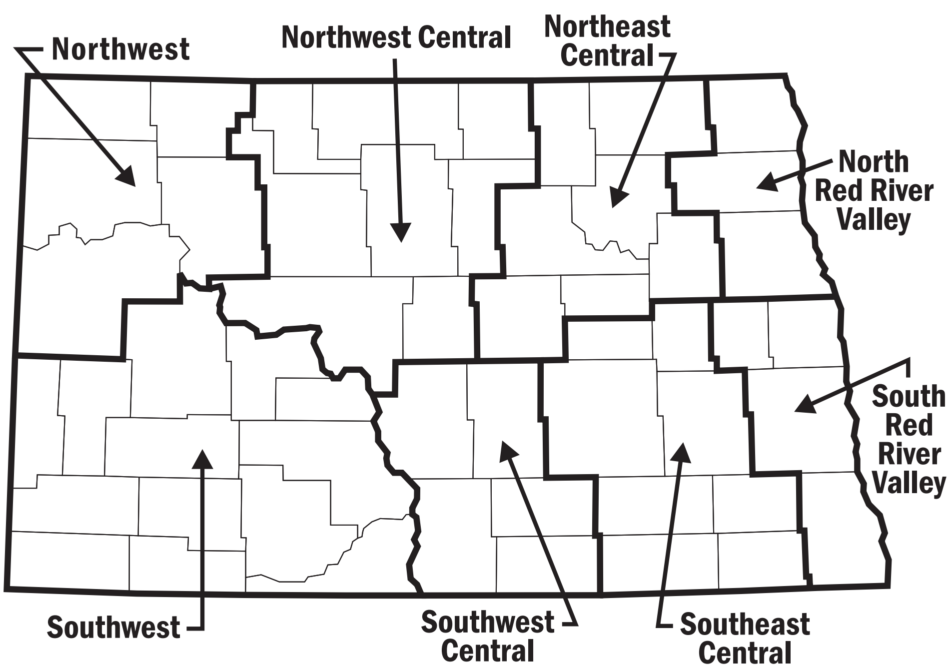

Figure 1. State areas used in summarizing soil test results for North Dakota.

Table 1. Average soil test values from 1992-91 by county and region and state from NDSU-tested fields 1953-2001.

Area	County	Average Soil Test Values, 1992-2001 pH	Nitrogen Cropped	Fallowed	Phosphorus	Potassium		Fields Tested 1953-2001
			lb/acre-2'	lb/acre-2'	ppm	ppm		
North Red River Valley	Grand Forks	7.8	62	99	13.5	261		13,276
	Pembina	7.2	47	110	18	371		13,701
	Walsh	7.3	55	97	17	498		9,524
Average of Counties		7.3	52	106	16.5	364	Total	36,501
South Red River Valley	Cass	7.5	45	104	13.5	328		57,399
	Richland	7.5	45	85	13.5	295		25,883
	Steele	7.5	59	119	13.5	291		9,630
	Traill	7.9	62	136	22	540		20,393
Average of Counties		7.6	47	107	15	355	Total	113,305
Northeast Central	Benson	7.5	54	83	10.5	417		8,107
	Cavalier	7.8	53	111	6.5	439		6,388
	Eddy	7.5	52	83	10	230		5,795
	Nelson	7.8	45	84	10.5	378		7,392
	Ramsey	7.9	51	110	14	459		7,096
	Towner	7.7	46	86	14	511		8,284
	Wells	7.6	54	93	10	361		18,209
Average of Counties		7.6	52	90	10.5	340	Total	61,271
Southeast Central	Barnes	7.4	48	119	10.5	331		14,244
	Dickey	7.2	45	74	13.5	480		8,661
	Foster	7.5	52	95	10.5	261		4,210
	Griggs	7.1	55	109	15.5	485		4,090
	LaMoure	7.0	50	91	13	427		13,729
	Ransom	7.4	60	62	16.5	235		3,442
	Sargent	7.5	66		15	470		4,618
	Stutsman	7.3	54	81	11	300		22,783
Average of Counties		7.3	51	89	12	365	Total	75,777
Northwest Central	Bottineau	7.5	46	91	12	522		13,467
	McHenry	7.5	52	80	11.5	361		6,757
	McLean	7.7	77	116	19	352		5,869
	Pierce	7.6	46	76	9	327		5,927
	Renville	7.6	56	99	13.5	624		4,671
	Rolette	7.6	52	139	11	441		4,376
	Sheridan	7.2	49	72	13.5	404		3,904
	Ward	7.3	65	143	13.5	562		9,038
Average of Counties		7.5	51	93	13	462	Total	54,009
Southwest Central	Burleigh	7.4	52	253	25.5	566		4,065
	Emmons	7.1	41	102	15.5	508		2,374
	Kidder	7.6	99	86	15.5	504		1,784
	Logan	7.0	63	102	11.5	472		2,663
	McIntosh	6.9	47	115	9.5	456		4,848
Average of Counties		7.1	50	117	15.5	500	Total	15,734
Northwest	Burke	7.3	60	113	11	430		2,494
	Divide	7.9	43	52	8	300		4,639
	McKenzie	7.6	47	83	13	477		3,991
	Mountrail	7.4	61	101	12.5	511		6,602
	Williams	7.7	41	49	7	252		9,165
Average of Counties		7.7	48	59	10	374	Total	26,891
Southwest	Adams	7.3	60	107	8.5	305		3,473
	Billings	7.1	49	81	9.5	247		983
	Bowman	7.7	43	93	23.5	345		3,883
	Dunn	6.7	46	79	13.5	294		6,322
	Golden Valley	7.9	41	77	16.5	521		2,119
	Grant	7.3	116	82	19	384		2,290
	Hettinger	7.1	40	90	16	837		5,405
	Mercer	7.8	80	67	26.5	630		3,790
	Morton	6.9	47	80	12.5	380		8,866
	Oliver	6.6	41	85	10	287		3,627
	Sioux	6.7	50	162	13	325		305
	Slope	7.2	55	56	16	376		2,652
	Stark	7.3	66	106	16	523		6,066
Average of Counties		7.0	46	85	15.5	443	Total	49,781
Grand Total of Number of Fields Tested in North Dakota								433,269
State Average 1992-2001		7.4	49	83	14	398		
State Average 1982-1991		7.4	69	109	19	558		
State Average 1972-1981		7.6	60	105	17	390*		

* From 1972-1981, any potassium soil test above 500 was reported 500+; since 1982, the actual value was recorded.

Table 2. Number of farmers' fields and samples tested by NDSU Soil Testing Laboratory, 1953-2001

Year	North Dakota	Others	Total	Additional nitrate-N tests analyzed*	Total
1953/54	2,188	-	2,188		2,188
1954/55	1,904	-	1,904		1,904
1955/56	2,892	-	2,892		2,892
1956/57	4,439	-	4,439		4,439
1957/58	5,216	-	5,216		5,216
1958/59	5,129	72	5,201		5,201
1959/60	4,420	48	4,468		4,468
1960/61	12,682	199	12,881		12,881
1961/62	6,157	-	6,157		6,157
1962/63	6,341	149	6,490		6,490
1963/64	7,327	87	7,414		7,414
1964/65	5,275	112	5,387		5,387
1965/66	3,521	103	3,624		3,624
1966/67	8,378	273	8,651		8,651
1967/68	9,530	243	9,773		9,773
1968/69	4,193	274	4,467	1,144	5,611
1969/70	5,920	597	6,517	598	7,115
1970/71	5,362	411	5,773	3,454	9,227
1971/72	4,715	723	5,438	4,003	9,441
1972/73	9,581	829	10,410	8,091	18,501
1973/74	10,934	2,737	13,671	10,077	23,748
1974/75	12,557	3,968	16,525	11,802	28,327
1975/76	22,626	7,235	29,861	21,385	51,246
1976/77	29,969	9,104	39,073	30,456	69,529
1977/78	15,773	5,507	21,280	16,789	38,069
1978/79	16,219	6,982	23,201	20,061	43,262
1979/80	13,627	5,258	18,885	15,681	34,566
1980/81	20,884	9,201	30,085	25,076	55,161
1981/82	21,041	7,220	28,261	25,480	53,741
1982/83	15,630	5,535	21,165	8,843	40,008
1983/84	16,512	4,983	21,495	19,070	40,565
1984/85	12,428	4,678	17,106	14,794	31,900
1985/86	10,469	2,834	13,303	10,956	24,259
1986/87	8,709	3,477	12,186	10,000	22,186
1987/88	8,880	3,333	12,213	9,419	21,632
1988/89	9,612	3,882	13,494	10,568	24,062
1989/90	10,599	4,040	14,639	11,550	26,189
1990/91	10,368	3,396	13,764	10,332	24,096
1991/92	7,837	3,343	11,180	9,714	20,894
1992/93	6,386	2,601	8,987	8,234	17,221
1993/94	5,386	2,239	7,625	6,802	14,427
1994/95	5,373	2,068	7,441	6,502	13,943
1995/96	4,407	1,552	5,959	5,507	11,466
1996/97	5,082	1,615	6,697	5,842	12,539
1997/98	5,500	1,220	6,720	5,836	12,556
1998/99	4,619	1,098	5,717	4,981	10,698
1999/2000	4,253	1,118	5,371	4,616	9,987
2000/2001	2,134	974	3,108	2,559	5,667
Total 1991/2001	50,977	17,828	68,805	60,593	129,398
Total 1953/2001	432,984	115,318	548,302	370,222	918,524

* 2 or more samples are analyzed from a field for NO_3-N

Time of Soil Sampling

Soil samples can be taken and analyzed at any time during the year. However, samples to be analyzed for available nitrogen should be taken from small-grain harvest in late summer until spring planting time in North Dakota. For this and other reasons that include farmer workload, ease of sampling and clean fields following harvest, most fields (approximately 75 percent) are sampled and analyzed in the fall. The large number of samples that need to be analyzed during this brief time period sometimes causes processing delays. Normally, samples are analyzed and results returned to growers in five days or less.

Soil pH

Acid pH can be present in any field. Inclusions of acid pH occur in fields in which composite soil samples indicate alkaline (pH>7) pH. In terms of composite testing, more than 79 percent of the fields in North Dakota have a pH of 7.0 or above (Table 3).

The pH of surface soil in North Dakota tends to increase from west to east. Nearly 50 percent of the fields tested in the southwestern region have a pH of 6.9 or less, while only about 11 percent of the fields in the southern Red River Valley and 27 percent of the fields in the northern Red River Valley have pH values in this range. The percentage of fields in the various pH ranges varies from year to year (Table 4), but no average change in pH has occurred since the previously reported 10-year period (Dahnke et al., 1992).

Differences in pH between regions reflect differences in soil parent material or cropping practices. Note that the most acidic soils are present in the southwest, which matches survey data collected by Franzen (1999) and Franzen et al. (2006).

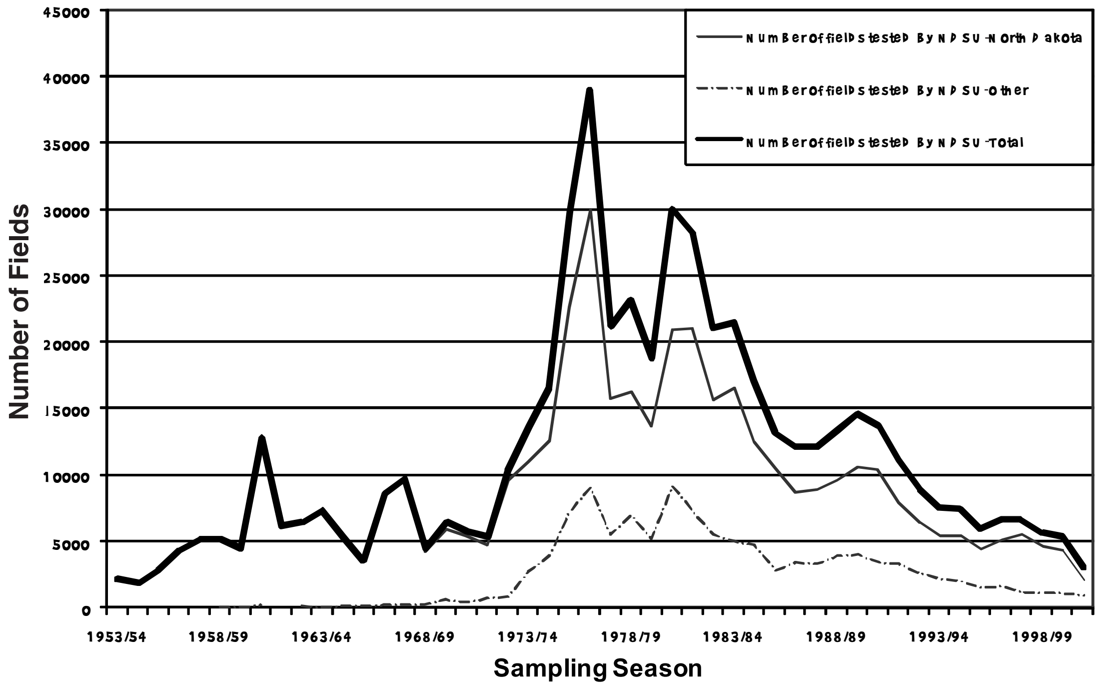

Figure 2. Number of fields tested by the NDSU Soil Testing Laboratory 1953-2001.

Table 3. Total number of fields tested for pH and the percentage in seven pH ranges for eight areas in North Dakota, 1991-2001.

		pH ranges						
Region	**Fields**	**<5.4**	**5.5-5.9**	**6.0-6.4**	**6.5-6.9**	**7.0-7.4**	**7.5-7.9**	**>8.0**
		% of fields						
North Red River Valley	3,552	0	1	4	22	29	27	27
South Red River Valley	9,412	<1	<1	2	8	23	50	16
Northeast Central	4,136	<1	<1	2	8	22	43	25
Southeast Central	3,689	<1	1	6	18	36	32	7
Northwest Central	1,396	0	1	3	11	28	44	13
Southwest Central	1,281	4	1	17	30	21	23	7
Northwest	869	0	1	1	6	18	41	33
Southwest	2,279	<1	7	20	23	23	18	9
North Dakota	26,614	<1	1	5	14	25	39	16

Table 4. Total number of North Dakota fields tested for pH and percentage of fields in six pH ranges, 1991-2001.

		pH ranges					
Year	**Fields**	**<5.9**	**6.0-6.4**	**6.5-6.9**	**7.0-7.4**	**7.5-7.9**	**>8.0**
		% of fields					
1991/92	5,074	1	5	15	24	41	16
1992/93	4,245	1	5	16	27	41	11
1993/94	2,708	1	8	17	25	38	11
1994/95	2,584	2	9	15	26	35	12
1995/96	1,671	1	6	15	26	39	13
1996/97	1,871	<1	3	12	25	40	20
1997/98	2,018	1	4	10	24	38	23
1998/99	1,785	1	3	10	29	39	19
1999/2000	2.053	2	5	14	24	36	20
2000/01	835	2	2	11	21	40	21
Total	24,844	1	5	14	25	39	16

Nitrate-N (NO_3-N)

Nitrogen is the nutrient most often deficient in North Dakota soils. It also is the nutrient that varies most in county, regional and state field averages from year to year. The amount of nitrogen released through organic matter decomposition, the amount used in crop growth and losses of nitrogen by leaching and denitrification vary depending on weather conditions. Most nitrogen fertilizer recommendations in North Dakota are based on the NO_3-N available in the top 2 feet of soil in each field each year.

The level of NO_3-N in a field is hardly ever completely stable throughout the post-harvest period until spring, except when the soil is frozen. However, soil samples taken in early August generally are similar in nitrogen to samples taken in September, October and November (Table 5) unless unusually large organic matter/residue mineralization or immobilization results from a combination of climatic and soil factors. Slightly higher soil nitrogen values in August may be the result of later fall immobilization by crop residues or a large leaching event. Higher levels later in the fall could be caused by abnormally warm and moist soil conditions. The amount of residual NO_3-N found in the top 2 feet of soil varies among years (Table 6). Cropped fields generally have lower residual nitrate levels

Table 5. Average nitrate nitrogen in the top 2 feet of cropped and fallowed North Dakota fields sampled from August through November 1992-2001.

		Region of North Dakota								
Month	Cropping history	North Red River Valley	South Red River Valley	Northeast Central	Southeast Central	Northwest Central	Southwest Central	Northwest	Southwest	Statewide
		Mean nitrate-N/acre 2-feet								
August	Cropped	50	54	55	60	61	NA*	NA	19	54
September	Cropped	69	52	54	54	49	41	49	41	52
October	Cropped	45	45	50	46	47	44	43	47	46
November	Cropped	50	47	48	51	50	39	52	43	47
Sept.-Nov.	Cropped	51	47	51	50	48	43	47	45	48
August	Fallow	102	107	19	94	NA	NA	30	64	96
September	Fallow	117	122	108	84	87	100	58	85	92
October	Fallow	99	102	85	108	92	116	59	93	86
November	Fallow	89	138	103	82	105	109	48	84	77
Sept.-Nov.	Fallow	106	113	93	90	93	114	56	88	86

* Data not available.

Table 6. Percent of cropped and fallowed fields in several nitrate-N categories by year, 1992-2001.

		Nitrate-N Soil Test lb N/acre 2-feet										
Year	Fields	0-19	20-39	40-59	60-79	80-99	100-119	120-139	140-159	160-179	180-199	>200
Cropped		% of cropped fields										
1991/92	6,024	1	26	31	19	10	5	3	1	1	<1	1
1992/93	5,323	22	37	20	10	5	3	1	<1	<1	<1	<1
1993/94	4,520	22	42	19	8	4	2	1	<1	<1	<1	<1
1994/95	4,476	16	32	22	13	7	4	2	<1	<1	<1	1
1995/96	3,815	17	34	22	12	6	3	2	1	<1	<1	<1
1996/97	4,546	21	33	20	12	6	3	2	1	<1	<1	1
1997/98	4,772	11	29	24	15	9	5	3	2	1	<1	1
1998/99	3,970	17	32	22	12	8	3	2	1	<1	<1	<1
1999/00	3,651	19	37	24	10	5	2	1	<1	<1	<1	<1
2000/01	1,800	19	34	24	12	5	3	1	<1	<1	<1	<1
Fallow		% of fallowed fields										
1991/92	762	<1	3	11	17	19	18	10	7	6	3	5
1992/93	531	1	7	16	20	19	13	9	5	4	2	4
1993/94	489	3	25	29	20	10	6	3	1	0	<1	<1
1994/95	476	8	24	22	13	10	8	6	3	3	1	2
1995/96	321	3	19	20	12	14	7	6	6	3	3	6
1996/97	253	4	12	25	19	15	8	7	4	3	1	2
1997/98	301	4	22	25	18	8	8	5	3	3	2	1
1998/99	265	1	12	24	20	15	11	3	3	3	1	3
1999/00	287	2	19	18	16	14	11	7	4	2	2	4
2000/01	97	5	37	14	10	4	5	11	3	7	1	1

compared with fallowed fields. During the 10-year period covered by this report, about 16 percent of the cropped soils had less than 20 pounds of NO_3-N per acre, while only 3 percent of the fallowed fields had these levels of residual NO_3-N. On the other hand, only 8 percent of the cropped fields had greater than 100 pounds of residual NO_3-N per acre, while 28 percent of the fallowed fields had residual N levels in this range. This trend also can be seen statewide (Table 7).

Extractable Phosphorus

In contrast to NO_3-N soil test levels, county, regional and statewide average phosphorus (P) tests do not vary much from year to year. Testing a field for P each year generally is not necessary. Before 1992, phosphorus soil tests were reported in pounds per acre (Table 8a). However, since the phosphorus soil test does not directly measure the amount of phosphorus in the soil but rather the ablility of the soil to supply phosphorus to the crop, the soil test reports were changed to parts per million (ppm) beginning in 1993. This did not change the general soil test categories for phosphorus. To convert ppm to pounds per acre values, multiply by 2.

The phosphorus soil test is determined on an extract of soil using a sodium bicarbonate solution (Dahnke, 1988). Phosphorus soil test results (Table 8b) are grouped into five categories. Soils that test between 0 and 3 ppm P in the 0 to 6-inch layer of soil are classed as very low. This means that the chance of a yield increase due to the application of phosphorus fertilizer is very high.

Soils that test between 4 and 7 ppm P (low) have an excellent chance of obtaining a yield response to applied fertilizer. Soils that test between 8 and 11 ppm P (medium) have about a 50 percent chance of a yield increase from phosphourus fertilizer. Crops growing on soils testing 12 to 15 ppm P (high) occassionally will have a yield increase due to fertilizer phosphorus application. Crops seldom respond to added phosphorus when the soil test is 16 ppm P or greater. Tables 8a and 8b (page 8) also include categories of soil test values within the very high soil test range because of the environmental concern of phosphorus runoff and subsequent eutrophication of surface waters.

Currently, soil test values indicate that < 6 percent of soils are in the very high category. Most of the fields in the very high category do not have excessive levels of P that would cause environmental concerns.

Environmentally, the changes during this 10-year period with respect to soils showing high P levels was favorable, with the number of fields testing greater than 16 ppm (high or very high) dropping from a high of about 70 percent in 1991 to an average of 15 percent in 2001 (Figure 3, page 8).

Table 7. Percent of cropped and fallowed fields in several nitrate-nitrogen ranges for the eight soil test areas in North Dakota, 1992-2001.

			Nitrate-N Soil Test lb N/acre 2-feet										
Region	**Cropping**	**Fields**	**0-19**	**20-39**	**40-59**	**60-79**	**80-99**	**100-119**	**120-139**	**140-159**	**160-179**	**180-199**	**>200**
		number	% of fields in each range										
N-RRV	Cropped	4,008	17	30	22	13	8	5	2	2	<1	<1	1
	Fallow	257	21	7	12	17	16	16	11	5	8	2	5
S-RRV	Cropped	13,272	16	36	23	12	6	3	1	<1	<1	<1	<1
	Fallow	388	1	6	14	14	17	17	9	7	4	3	6
NEC	Cropped	6,427	12	32	24	15	8	4	2	1	<1	<1	<1
	Fallow	298	2	9	14	21	19	10	8	6	2	3	4
SEC	Cropped	5,187	13	32	24	14	7	4	3	1	<1	<1	<1
	Fallow	315	4	12	13	19	16	15	10	3	3	2	3
NWC	Cropped	5,095	12	32	26	13	8	4	2	1	<1	<1	<1
	Fallow	444	1	11	16	20	17	13	7	6	4	2	3
SWC	Cropped	2,116	17	35	21	12	6	3	2	1	1	<1	1
	Fallow	106	2	7	16	19	12	10	8	6	8	2	8
NW	Cropped	2,080	26	28	19	11	6	4	2	<1	<1	<1	2
	Fallow	1,136	5	30	29	15	8	4	3	2	1	<1	1
SW	Cropped	5,281	19	35	21	11	6	3	2	<1	<1	<1	1
	Fallow	838	3	10	21	17	16	11	7	5	4	2	3
State-wide	Cropped	43,454	16	33	23	13	7	4	2	1	<1	<1	<1
	Fallow	3,782	3	16	20	17	14	10	7	4	3	2	3

* N-RRV = North Red River Valley, S-RRV = South Red River Valley, NEC = Northeast Central, SEC = Southeast Central, NWC = Northwest Central, SWC = Southwest Central, NW = Northwest, SW = Southwest

Table 8a. Total number of North Dakota fields tested for phosphorus from 1992 and the percent in several soil test categories.

		Phosphorus Soil Test, lb P/acre											
		Low	Medium	High	Very High								
Year	Fields	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-119	120-139
		% of fields											
1991/92	6,404	8	42	28	12	4	2	<1	<1	<1	<1	<1	<1

Table 8b. Total number of North Dakota fields tested for phosphorus for 1993-2001 and the percent in several soil test categories.

		Phosphorus Soil Test, ppm											
		Very Low	Low	Medium	High	Very High							
Year	Fields	0-3	4-7	8-11	12-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56+
		% of fields												
1992/93	5,395	2	30	19	8	3	1	<1	<1	<1	<1	<1	<1	<1
1993/94	4,631	3	35	15	6	2	1	<1	<1	<1	<1	<1	<1	<1
1994/95	4,606	4	33	16	8	3	1	<1	<1	<1	<1	<1	<1	<1
1995/96	3,714	7	41	12	6	2	1	<1	<1	<1	<1	<1	<1	<1
1996/97	4,208	9	39	11	5	2	1	<1	<1	<1	<1	<1	<1	<1
1997/98	4,730	6	36	14	6	3	1	<1	<1	<1	<1	<1	<1	<1
1998/99	4,007	6	37	13	5	2	1	<1	<1	<1	<1	<1	<1	<1
1999/00	3,640	11	41	10	5	3	1	<1	<1	<1	<1	<1	<1	<1
2000/01	1,749	9	40	10	6	2	1	1	<1	<1	<1	<1	<1	<1
1992-2001	36,680	6	36	14	6	3	1	1	<1	<1	<1	<1	<1	<1

Agronomically, however, the changes during this period for the number of fields in the very low or low range is troubling, with fields testing in the low categories rising from 8 percent in 1992 to nearly 50 percent in 2001.

Approximately 40 percent of the fields tested between 1992 and 2001 tested very low or low in P (Tables 8a & 8b). This is compared with 23 percent reported in the previous 10-year period and the 70 percent reported in the 1953 to 1960 soil test summary by Bauer (1960). These differences reflect changes in phosphorus fertilizer usage based on changes in cropping practices, fertilizer prices, commodity prices and weather patterns that influence fertilizer application and crop utilization. Generally, phosphorus soil test values decrease from east to west across the state (Table 9). The long-term trends in soil test phosphorus are shown in Figure 3 and phosphorus fertilizer use is shown in Figure 4.

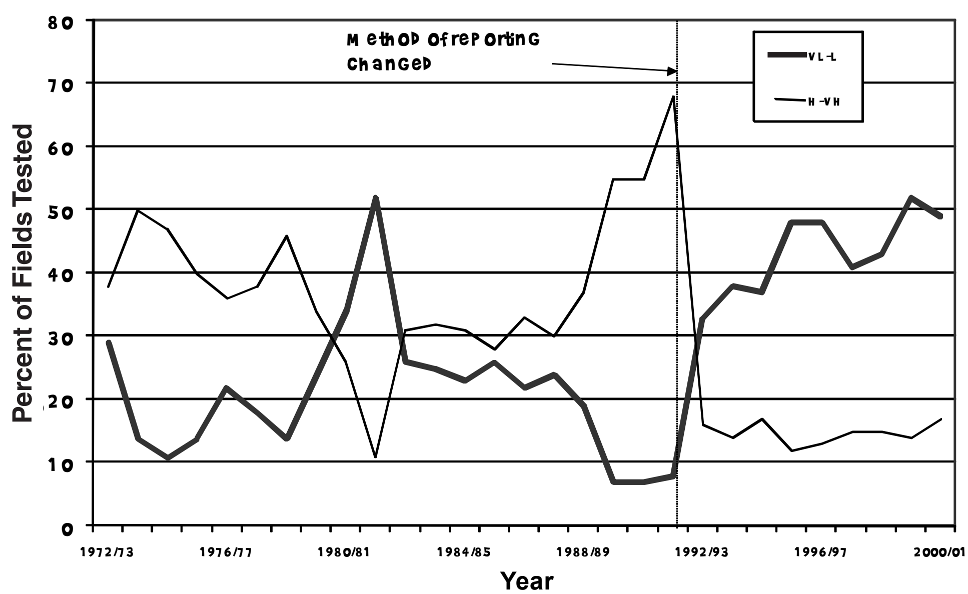

Figure 3. Thirty-year soil test phosphorus trends 1972-2001. Methods of reporting soil but values changed from pounds per acre to parts per million in 1992.

Extractable Potassium

North Dakota soils are naturally high in potassium (K). Of the fields tested, > 98 percent were in the high and very high categories (Table 10a & 10b). Unlike nitrogen and phosphorus, the potassium soil test level increases from east to west (Table 11, page 10). During the past nine years, no detectable change has been observed in soil potassium levels (Table 10) from the previous 10-year period. The 30-year trend also shows that little change has occurred in soil test potassium levels (Figure 5). Potassium-deficient soils in North Dakota usually are sandy in texture, particularly on ancient beach lines of the former Lake Agassiz in the Red River Valley.

Beginning in 1993, potassium soil test reports were changed from pounds per acre to parts per million (ppm). To convert ppm to pounds per acre values, multiply by 2.

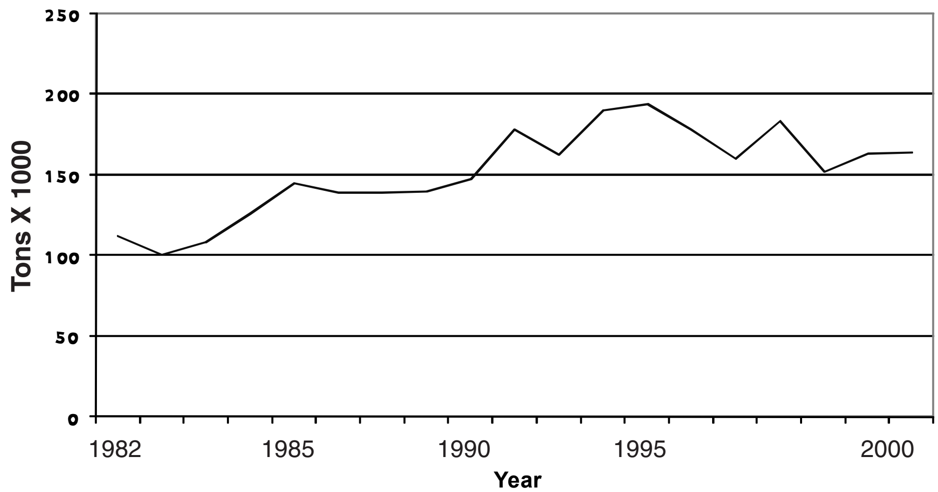

Figure 4. Trends in phosphorus fertilizer usage in North Dakota, 1982-2000.

Table 9. Percentage of fields in five soil test phosphorus categories for eight regions within North Dakota, 1992-2001.

	Phosphorus Soil Test, ppm					
Region	Very Low	Low	Medium	High	Very High	Total Fields
	% of fields					
N-RRV	3	25	27	15	30	3,585
S-RRV	3	30	32	18	17	11,316
NEC	5	46	32	11	7	5,002
SEC	4	37	32	15	11	4,470
NWC	7	43	28	12	11	2,612
SWC	15	46	20	7	11	1,931
NW	19	51	18	6	6	2,603
SW	5	35	29	14	18	5,161
Statewide	6	36	29	14	15	36,680

Table 10a. Total number of North Dakota fields tested for potassium for 1991-92 and the percentage falling into several soil test categories.

	Potassium Soil Test, lb K/acre											
	Low	Medium	High	Very High								
Fields	0-99	100-149	150-199	200-249	250-299	300-349	350-399	400-449	450-499	500-599	600-699	700-799	>800
5,741	<1	<1	1	3	5	6	7	8	8	16	13	10	23

Table 10b. Total number of North Dakota fields tested for potassium for 1992-2001 and the percentage falling into several soil test categories.

		Potassium Soil Test, ppm												
		Low	Medium	High	Very High									
Year	Fields	0-40	41-80	81-120	121-160	161-200	201-225	226-250	251-275	276-300	301-325	326-350	351-375	>375
1992/93	4,784	<1	1	6	10	13	8	9	6	9	5	7	4	21
1993/94	3,720	<1	1	6	10	14	9	8	9	8	5	6	5	17
1994/95	3,956	<1	1	5	9	13	8	8	8	8	7	7	5	20
1995/96	2,847	0	<1	3	9	15	10	10	7	8	7	7	5	19
1996/97	3,138	<1	1	5	11	13	9	8	8	7	7	5	5	20
1997/98	3,271	<1	2	7	11	13	8	8	8	6	6	6	4	20
1998/99	2,976	<1	3	9	12	8	8	7	7	6	7	7	4	26
1999/00	2,664	<1	1	5	9	10	7	7	7	8	6	7	6	26
2000/01	1,206	<1	2	7	11	11	8	8	7	7	6	6	4	23
1992/2001	28,562	<1	1	5	10	13	8	8	8	8	6	6	5	21

Sulfate-Sulfur

A test for sulfate-sulfur has been offered since 1976, but few samples were tested until recent years. An increasing number of sulfur deficiencies seen in crops, especially canola, has resulted in an increase in the number of soil samples tested for sulfate-sulfur. Sulfate-S is reported in pounds per acre, usually for a composite soil sample resulting from multiple 2-foot soil cores.

The agronomic value of this soil test is debatable, with many soil scientists, including most in North Dakota, agreeing that it is a poor predictor of future available sulfur to most crops, with the exception of alfalfa. However, due to demand for the test by clients and the lack of a substitute test, the test continues to be offered. Table 12a summarizes the percentage of samples falling into several soil test categories in 1992 in each of the eight reporting regions.

A slight adjustment was made in the soil test categories beginning in 1993. The percentage of samples falling into the soil test categories between 1993 and 2001 are summarized in Table 12b.

About 14 percent of the fields tested are in the range where a response to sulfur could occur. The greatest concentration of very low and low testing soils is found in the southwest central, northwest and southwest regions of the state.

Sulfur used to be added to the soil by rainfall in relatively large quantities, but during the last 20 years, levels of S in rainfall have decreased (Franzen and Grant, 2008). Sulfur also is released through organic matter and residue decomposition. Many soils in the state contain accummulations of gypsum (calcium sulfate) within the rooting zone of soils and in the groundwater that

Table 11. Percentage of fields in five potassium soil test categories for eight regions of North Dakota, 1991-2001.

	Potassium Soil Test, ppm					
Region	Very Low 0-40	Low 41-80	Medium 81-120	High 121-160	Very High 161+	Total Fields
	% of fields					
N-RRV	0.1	1.5	5.6	10.0	82.9	3,313
S-RRV	0.1	2.7	9.6	13.8	73.8	10,070
NEC	0.04	0.1	1.9	8.4	89.6	4,544
SEC	0.1	0.6	2.0	6.6	90.7	3,613
NWC	0.1	1.1	3.0	5.5	90.3	1,246
SWC	0.0	0.1	0.9	3.6	95.4	1,184
NW	0.1	0.8	5.0	11.5	82.6	2,075
SW	0.1	0.4	1.4	6.6	91.5	2,517
Statewide	0.1	1.4	5.2	10.0	83.3	28,562

Table 12a. Percentage of fields in five sulfate-S soil test categories for eight regions of North Dakota, 1991/92.

		Sulfate-S, lb/acre 2-feet				
Region	Fields	Very Low 0-10	Low 11-20	Medium 21-30	High 31-40	Very High >40
		% of fields				
N-RRV	28	0	4	4	0	93
S-RRV	157	6	5	7	4	74
NEC	23	0	0	0	9	91
SEC	83	2	8	7	1	81
NWC	85	1	1	0	2	95
SWC	8	12	0	0	0	97
NW	35	9	26	14	14	37
SW	15	27	20	20	7	28
Statewide	434	5	7	6	4	79

Table 12b. Percentage of fields in five sulfate-sulfur soil test categories for eight areas of North Dakota, 1991-2001.

		Sulfate-S, lb/acre 2-feet				
Region	Fields	Very Low 0-9	Low 10-19	Medium 20-29	High 30-39	Very High >39
		% of fields				
N-RRV	148	5	4	8	5	77
S-RRV	685	4	5	4	6	80
NEC	594	2	3	2	3	90
SEC	540	2	8	8	8	73
NWC	458	4	7	6	9	73
SWC	184	14	15	14	10	48
NW	564	7	14	11	13	55
SW	656	9	12	10	12	57
Statewide	3829	8	7	8	7	70

moves into the root zone during wetter seasons. Sulfur defciencies in crops are relatively rare in soils with high organic matter (> 3 percent) but are much more common in low organic matter (< 3 percent), sandy soils after wet fall or spring seasons or fields seeded to canola (Franzen and Lukach, 2007). Data from 1991-92 has slightly different soil test categories, compared with other years.

Micronutrients

Zinc and iron are the two micronutrients most often lacking in North Dakota. Of the 3,503 fields tested for zinc between 1992 and 2001, 24 percent were rated as low if dry edible beans, corn, flax or potatoes were to be grown (Table 13, page 12). These data show little change from the 1982 to 1991 period (Dahnke et al., 1992). All other crops grown in North Dakota require less available zinc than these crops. The percentage of fields testing low in zinc by region is shown in Figure 6 (page 16).

Recently, the incidence of iron chlorosis symptoms has increased, especially in soybeans. Iron chlorosis is a complicated problem involving several soil and plant genetic factors and its occurance is not closely related with the iron soil test. Only 2 percent of the 1,014 fields tested for iron between 1992 and 2001 were in the low category (Table 14, page 13). The soil test iron data show no change from the 1982 to 1991 period (Dahnke et al., 1992). Increased incidence of iron chlorosis most likely is related to very wet growing season conditions from 1991 to 2001 and increased soybean acres seeded into fields with high calcium carbonate and salt levels.

Soil samples that were analyzed for copper and manganese are shown in Tables 15 and 16 (pages 14 and 15), respectively. No documented evidence is available for manganese deficiencies in the state; however, small grains occasionally may respond to copper if soil conditions are favorable for deficiency (Franzen et al, 2008). Five percent of the 965 fields tested for copper fell into the low soil test range.

Chloride (Table 17, page 16) sometimes is deficient for small grains. Of 6,278 fields tested, 30 percent of the fields were in the very low or low categories and 50 percent were in the high and very high categories. These values are similar to the data from the 1982 to 1991 period (Dahnke et al, 1992).

Soluble Salts

A soluble salt test (electrial conductivity or EC) often is conducted on soils suspected of having a salinity problem. For moderate-textured soils, conductivities of 0 to 1 millimhos per centimeter (mmhos/cm) are considered as nonsaline, 1 to 2 mmhos/cm as slightly saline, 2 to 4 mmhos/cm as moderately saline and greater than 4 mmhos/cm as strongly saline. Categories are slightly different for fine- or coarse-textured soils. Eighty-nine percent of the soils tested were in the nonsaline category and 97 percent were in the non- or slightly saline categories (Table 18, pages 17 and 18). These values were similar to those reported for the 1982 to 1991 period. The percentage of fields with a soluble salt problem was greatest in the Red River Valley and decreased from southeast to northwest across the state. The lack of change in average field tests documented by this data may be the result of soil samplers avoiding obviously saline areas to provide soil tests relevant to more productive areas of the field. Areas of salinity in fields across North Dakota have expanded during the wet period from 1992 to present.

Organic Matter

The organic matter test is not used in making nutrient recommendations. It is used only as an aid in making herbicide recommendations for those herbicides that are strongly absorbed on soil organic matter. It's also used as an indicator of soil quality. Soil organic matter levels decrease from east to west in North Dakota (Table 19). The mean soil organic matter level in the Red River Valley and the East Central area is between 4.1 percent and 4.5 percent. In the West Central area, the mean is 3.1 percent to 3.5 percent and in the West, it is 2.1 percent to 2.5 percent.

Table 13. Total number of fields analyzed for zinc and percentage of fields in zinc soil test categories, 1991-2001.

Region	Year	Fields	Zinc, ppm Low 0-0.5	Marginal 0.51-0.99	Adequate 1.0+
			——— % of fields ———		
N-RRV	1991/92	77	38	31	31
	1992/93	47	32	45	23
	1993/94	20	40	30	30
	1994/95	27	30	48	22
	1995/96	22	23	59	18
	1996/97	38	55	13	32
	1997/98	43	23	46	30
	1998/99	30	7	33	60
	1999/00	57	9	37	54
	2000/01	17	0	18	82
	1991/01	**378**	**27**	**36**	**37**
NEC	1991/92	36	44	22	33
	1992/93	14	43	29	29
	1993/94	7	29	29	43
	1994/95	17	6	65	29
	1995/96	14	50	43	7
	1996/97	11	9	54	36
	1997/98	18	6	50	44
	1998/99	23	39	30	30
	1999/00	21	24	62	14
	2000/01	10	20	60	20
	1991/01	**171**	**29**	**42**	**29**
NWC	1991/92	35	20	46	34
	1992/93	11	0	36	64
	1993/94	20	5	55	40
	1994/95	17	23	12	65
	1995/96	15	0	20	80
	1996/97	5	40	20	40
	1997/98	18	17	28	56
	1998/99	17	29	53	18
	1999/00	21	5	52	43
	2000/01	10	10	40	50
	1991/01	**169**	**14**	**39**	**47**
NW	1991/92	18	6	44	50
	1992/93	3	0	0	100
	1993/94	2	100	0	0
	1994/95	0	-	-	-
	1995/96	3	0	67	33
	1996/97	8	0	12	37
	1997/98	13	50	23	54
	1998/99	6	23	67	17
	1999/00	25	18	52	24
	2000/01	0	-	-	-
	1991/01	**78**	**22**	**40**	**38**
Statewide	1991/92	670	29	34	37
	1992/93	383	26	35	39
	1993/94	274	22	43	35
	1994/95	344	23	39	38
	1995/96	234	22	41	36

Region	Year	Fields	Zinc, ppm Low 0-0.5	Marginal 0.51-0.99	Adequate 1.0+
			——— % of fields ———		
S-RRV	1991/92	343	29	32	39
	1992/93	205	28	38	34
	1993/94	161	22	48	29
	1994/95	222	28	43	29
	1995/96	152	23	40	37
	1996/97	207	20	48	32
	1997/98	184	20	46	34
	1998/99	166	18	39	43
	1999/00	125	32	42	26
	2000/01	89	21	45	34
	1991/01	**1,854**	**24**	**41**	**34**
SEC	1991/92	137	27	39	34
	1992/93	63	22	24	54
	1993/94	41	5	19	76
	1994/95	16	6	37	56
	1995/96	16	12	62	25
	1996/97	24	8	37	54
	1997/98	81	14	41	46
	1998/99	84	25	40	34
	1999/00	78	29	33	37
	2000/01	34	21	56	23
	1991/01	**574**	**21**	**37**	**42**
SWC	1991/92	17	12	18	71
	1992/93	28	4	32	64
	1993/94	2	0	50	50
	1994/95	13	0	23	77
	1995/96	4	5	25	25
	1996/97	12	0	17	83
	1997/98	22	23	45	32
	1998/99	11	9	36	54
	1999/00	32	22	44	34
	2000/01	14	21	21	57
	1991/01	**155**	**13**	**32**	**54**
SW	1991/92	7	57	29	14
	1992/93	12	50	25	25
	1993/94	21	43	57	0
	1994/95	32	9	16	75
	1995/96	8	25	0	75
	1996/97	13	23	23	54
	1997/98	16	56	37	6
	1998/99	10	20	20	60
	1999/00	1	0	0	100
	2000/01	4	25	0	75
	1991/01	**124**	**31**	**27**	**42**
Statewide	1996/97	318	23	40	37
	1997/98	395	20	43	38
	1998/99	347	20	39	41
	1999/00	360	24	42	34
	2000/01	178	18	42	39
	1991/01	**3,503**	**24**	**39**	**37**

Table 14. Number of fields analyzed for iron and percentage in iron soil test categories, 1991-2001.

			Iron, ppm		
Region	Year	Fields	Low 0-0.5	Marginal 0.51-0.99	Adequate 1.0+
			——— % of fields ———		
N-RRV	1991/92	17	0	12	88
	1992/93	8	0	25	75
	1993/94	5	0	0	100
	1994/95	11	0	0	100
	1995/96	5	0	40	60
	1996/97	14	0	29	71
	1997/98	11	0	0	100
	1998/99	8	0	25	75
	1999/00	14	0	7	93
	2000/01	1	0	0	100
	1991/01	**94**	**0**	**15**	**85**
NEC	1991/92	7	0	14	86
	1992/93	4	0	0	100
	1993/94	0	-	-	-
	1994/95	6	0	33	67
	1995/96	0	-	-	-
	1996/97	0	-	-	-
	1997/98	1	0	0	100
	1998/99	0	-	-	-
	1999/00	6	17	0	83
	2000/01	3	0	33	67
	1991/01	**27**	**4**	**15**	**81**
NWC	1991/92	11	0	0	100
	1992/93	8	0	0	100
	1993/94	14	0	0	100
	1994/95	12	8	8	84
	1995/96	6	0	0	100
	1996/97	4	0	0	100
	1997/98	9	0	11	89
	1998/99	6	0	0	100
	1999/00	1	0	0	100
	2000/01	0	0	0	0
	1991/01	**71**	**1**	**3**	**96**
NW	1991/92	18	0	0	100
	1992/93	3	0	0	100
	1993/94	2	0	0	100
	1994/95	0	0	0	100
	1995/96	2	0	0	100
	1996/97	10	0	0	100
	1997/98	13	0	15	85
	1998/99	2	0	0	100
	1999/00	13	23	23	54
	2000/01	0	-	-	-
	1991/01	**63**	**5**	**8**	**87**
Statewide	1991/92	216	3	9	88
	1992/93	128	0	7	93
	1993/94	104	0	1	99
	1994/95	98	1	6	93
	1995/96	60	3	8	89
S-RRV	1991/92	95	7	14	79
	1992/93	36	0	6	94
	1993/94	33	0	0	10
	1994/95	25	0	12	88
	1995/96	27	0	4	96
	1996/97	41	2	20	78
	1997/98	44	0	7	93
	1998/99	33	6	3	91
	1999/00	29	0	0	100
	2000/01	22	0	4	96
	1991/01	**385**	**3**	**8**	**89**
SEC	1991/92	49	0	6	94
	1992/93	40	0	8	92
	1993/94	29	0	0	100
	1994/95	8	0	0	100
	1995/96	10	0	0	100
	1996/97	15	0	13	87
	1997/98	16	0	0	100
	1998/99	18	0	0	100
	1999/00	12	0	25	75
	2000/01	17	0	0	100
	1991/01	**214**	**0**	**5**	**95**
SWC	1991/92	13	0	0	100
	1992/93	26	0	8	92
	1993/94	1	0	0	100
	1994/95	10	0	0	100
	1995/96	3	0	33	67
	1996/97	2	0	0	100
	1997/98	6	0	0	100
	1998/99	2	0	0	100
	1999/00	19	0	21	79
	2000/01	2	0	0	100
	1991/01	**84**	**0**	**8**	**92**
SW	1991/92	6	0	0	100
	1992/93	3	0	0	100
	1993/94	20	0	5	95
	1994/95	26	0	0	100
	1995/96	7	29	14	57
	1996/97	9	0	0	100
	1997/98	4	0	0	100
	1998/99	0	-	-	-
	1999/00	1	0	0	100
	2000/01	0	-	-	-
	1991/01	**76**	**3**	**3**	**94**
Statewide	1996/97	95	1	15	84
	1997/98	104	0	6	94
	1998/99	69	3	4	93
	1999/00	95	5	12	83
	2000/01	45	0	4	96
	1991/01	**1,014**	**2**	**7**	**91**

Table 15. Number of fields analyzed for copper and the percentage in copper soil test categories, 1991-2001.

Region	Year	Fields	Copper, ppm Low 0-0.2	Marginal 0.21-0.60	Adequate >0.60
			% of fields		
N-RRV	1991/92	21	0	57	43
	1992/93	8	12	75	13
	1993/94	0	-	-	-
	1994/95	11	0	0	100
	1995/96	3	0	67	33
	1996/97	14	7	71	22
	1997/98	4	0	100	0
	1998/99	0	-	-	-
	1999/00	3	0	33	67
	2000/01	0	-	-	-
	1991/01	**64**	**3**	**55**	**42**
NEC	1991/92	7	0	57	43
	1992/93	4	0	50	50
	1993/94	1	0	0	100
	1994/95	6	0	83	17
	1995/96	0	-	-	-
	1996/97	0	-	-	-
	1997/98	0	-	-	-
	1998/99	1	0	0	100
	1999/00	6	0	33	67
	2000/01	1	0	0	100
	1991/01	**26**	**0**	**50**	**50**
NWC	1991/92	11	0	36	64
	1992/93	8	0	25	75
	1993/94	14	0	64	36
	1994/95	12	0	33	67
	1995/96	4	0	50	50
	1996/97	1	100	0	0
	1997/98	8	0	50	50
	1998/99	4	0	75	25
	1999/00	4	0	25	75
	2000/01	1	0	0	100
	1991/01	**67**	**2**	**43**	**55**
NW	1991/92	18	0	33	67
	1992/93	3	0	22	78
	1993/94	2	0	3	97
	1994/95	0	-	-	-
	1995/96	2	0	14	86
	1996/97	8	0	0	100
	1997/98	11	0	0	100
	1998/99	15	13	0	87
	1999/00	25	8	0	92
	2000/01	0	-	-	-
	1991/01	**84**	**5**	**6**	**89**
Statewide	1991/92	199	7	39	54
	1992/93	121	13	50	37
	1993/94	127	<1	57	42
	1994/95	91	1	37	62
	1995/96	48	6	54	40

Region	Year	Fields	Copper, ppm Low 0-0.2	Marginal 0.21-0.60	Adequate >0.60
			% of fields		
S-RRV	1991/92	79	11	25	43
	1992/93	23	0	65	13
	1993/94	22	0	64	0
	1994/95	16	6	63	100
	1995/96	18	6	61	33
	1996/97	28	0	82	22
	1997/98	28	4	57	0
	1998/99	25	4	64	0
	1999/00	47	2	51	67
	2000/01	25	0	56	0
	1991/01	**311**	**4**	**54**	**42**
SEC	1991/92	44	2	52	46
	1992/93	40	32	53	15
	1993/94	45	0	76	24
	1994/95	10	0	40	60
	1995/96	12	8	67	25
	1996/97	17	0	82	18
	1997/98	9	0	67	33
	1998/99	14	0	79	21
	1999/00	20	0	60	40
	2000/01	19	0	63	37
	1991/01	**230**	**7**	**63**	**30**
SWC	1991/92	13	15	46	39
	1992/93	26	0	46	54
	1993/94	13	0	46	54
	1994/95	10	0	40	60
	1995/96	2	0	0	100
	1996/97	1	0	100	0
	1997/98	8	0	75	25
	1998/99	2	0	100	0
	1999/00	11	0	36	64
	2000/01	2	0	100	0
	1991/01	**88**	**2**	**49**	**49**
SW	1991/92	6	33	50	17
	1992/93	9	22	11	67
	1993/94	30	3	33	63
	1994/95	26	0	27	73
	1995/96	7	14	43	43
	1996/97	5	0	40	60
	1997/98	4	0	0	100
	1998/99	4	0	50	50
	1999/00	2	0	0	100
	2000/01	2	0	0	100
	1991/01	**95**	**6**	**30**	**64**
Statewide	1996/97	74	3	69	28
	1997/98	72	1	53	46
	1998/99	65	5	66	29
	1999/00	118	2	45	52
	2000/01	50	0	56	44
	1991/01	**965**	**5**	**50**	**45**

Table 16. Number of fields analyzed for manganese and the percentage in soil test categories, 1991-2001.

Region	Year	Fields	Manganese, ppm 0-1.0	Manganese, ppm >1.0
			% of fields	% of fields
N-RRV	1991/92	17	0	100
	1992/93	8	0	100
	1993/94	0	-	-
	1994/95	11	0	100
	1995/96	1	0	100
	1996/97	9	11	89
	1997/98	4	0	100
	1998/99	0	-	-
	1999/00	1	0	100
	2000/01	1	0	100
	1991/01	**52**	**2**	**98**
NEC	1991/92	7	0	100
	1992/93	4	0	100
	1993/94	1	0	100
	1994/95	6	0	100
	1995/96	0	-	-
	1996/97	0	-	-
	1997/98	0	-	-
	1998/99	0	-	-
	1999/00	1	0	100
	2000/01	1	0	100
	1991/01	**20**	**0**	**100**
NWC	1991/92	11	0	100
	1992/93	8	0	100
	1993/94	14	0	100
	1994/95	10	0	100
	1995/96	3	0	100
	1996/97	1	0	100
	1997/98	8	0	100
	1998/99	0	-	-
	1999/00	1	0	100
	2000/01	0	-	-
	1991/01	**56**	**0**	**100**
NW	1991/92	18	0	100
	1992/93	3	0	100
	1993/94	2	0	100
	1994/95	0	-	-
	1995/96	2	0	100
	1996/97	7	14	86
	1997/98	11	0	100
	1998/99	1	0	100
	1999/00	13	23	77
	2000/01	1	0	0
	1991/01	**58**	**7**	**93**
Statewide	1991/92	203	<1	99
	1992/93	125	0	100
	1993/94	91	1	99
	1994/95	87	0	100
	1995/96	43	0	100
S-RRV	1991/92	87	1	99
	1992/93	26	0	100
	1993/94	24	0	100
	1994/95	17	0	100
	1995/96	18	0	100
	1996/97	24	4	96
	1997/98	29	0	100
	1998/99	25	0	100
	1999/00	23	0	100
	2000/01	23	0	100
	1991/01	**296**	**<1**	**99**
SEC	1991/92	44	0	100
	1992/93	40	0	100
	1993/94	29	0	100
	1994/95	6	0	100
	1995/96	10	0	100
	1996/97	12	0	100
	1997/98	9	0	100
	1998/99	7	0	100
	1999/00	1	0	100
	2000/01	16	0	100
	1991/01	**174**	**0**	**100**
SWC	1991/92	13	0	100
	1992/93	26	0	100
	1993/94	1	0	100
	1994/95	10	0	100
	1995/96	2	0	100
	1996/97	1	0	100
	1997/98	4	0	100
	1998/99	2	0	100
	1999/00	9	0	100
	2000/01	0	-	-
	1991/01	**68**	**0**	**100**
SW	1991/92	6	0	100
	1992/93	10	0	100
	1993/94	20	5	95
	1994/95	27	0	100
	1995/96	7	0	100
	1996/97	6	0	100
	1997/98	4	0	100
	1998/99	0	-	-
	1999/00	0	-	-
	2000/01	0	-	-
	1991/01	**80**	**1**	**99**
Statewide	1996/97	60	5	95
	1997/98	69	0	100
	1998/99	35	0	100
	1999/00	49	0	100
	2000/01	42	0	100
	1991/01	**804**	**1**	**99**

Table 17. Number of fields analyzed for chloride and percentage of fields in several categories, 1991-2001.

Year	Fields	Very low 0-14	Low 15-29	Medium 30-44	High 45-59	Very High 60+	MeanTest
		Chloride Soil Test, lb/acre 2-feet					
		% of fields					
1991/92	336	8	26	18	16	32	60
1992/93	449	4	20	17	11	48	81
1993/94	511	2	11	20	18	50	81
1994/95	570	3	16	16	14	50	84
1995/96	588	10	24	19	13	33	66
1996/97	1,221	10	24	17	12	36	64
1997/98	959	9	26	20	16	30	66
1998/99	672	11	25	24	15	25	52
1999/00	700	8	24	28	17	23	51
2000/01	242	3	23	20	18	37	67
1991/01	**6,278**	**8**	**23**	**20**	**15**	**35**	**66**

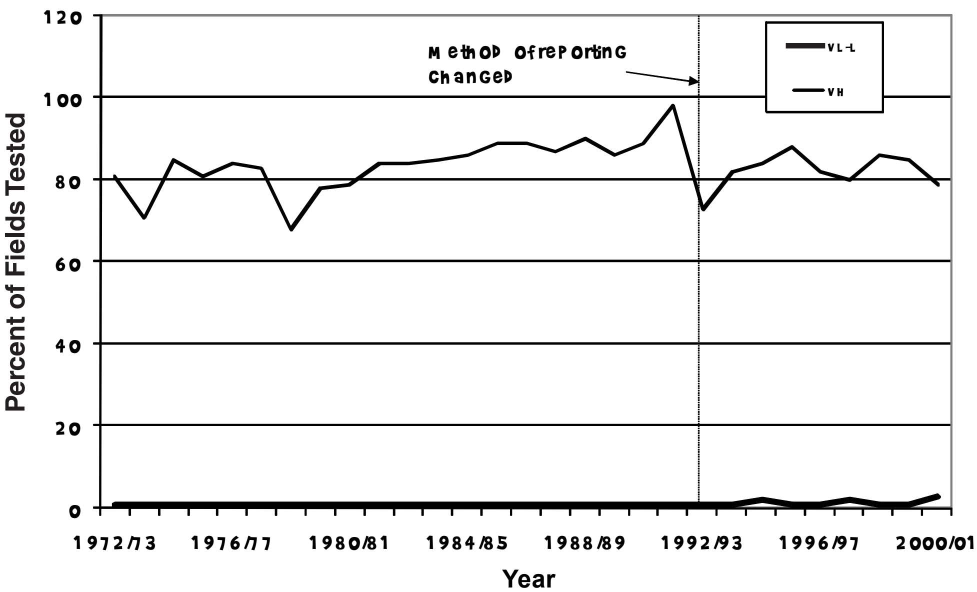

Figure 5.

Thirty-year soil test potassium trends 1972-2001.

Method of reporting soil test values changed from pounds per acre to parts per million in 1992.

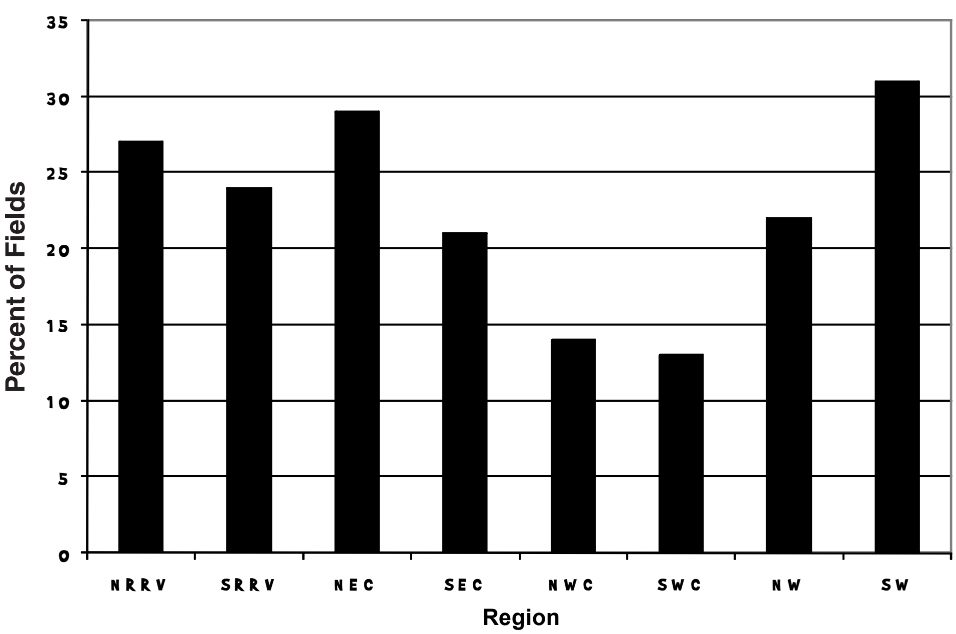

Figure 6.

Percentage of fields testing low in zinc reported by region 1991-2001.

Table 18. Percent of fields in several soluble salt categories measured in a 1:1 soil-to-water suspension in eight regions of North Dakota, 1991-2001. Soil samples taken from a 0 to 6-inch depth.

			Electrical conductivity (mmhos/cm)						
Region	**Year**	**Fields**	**0-0.5**	**0.51-1.0**	**1.01-1.5**	**1.51-2.0**	**2.01-3.0**	**3.01-4.0**	**>4.0**
N-RRV	1991-92	27	30	52	7	7	4	0	0
	1992/93	23	43	30	4	4	3	4	9
	1993/94	12	25	25	8	8	17	0	17
	1994/95	3	67	0	33	0	0	0	0
	1995/96	3	67	0	33	0	0	0	0
	1996/97	15	20	67	7	0	0	0	7
	1997/98	9	11	22	11	22	22	11	0
	1998/99	14	57	21	0	14	7	0	0
	1999/00	11	18	36	27	9	0	0	9
	2000/01	17	18	58	12	0	0	6	6
	1991/01	**134**	**31**	**40**	**10**	**7**	**5**	**2**	**5**
S-RRV	1991/92	361	45	47	4	2	<1	<1	<1
	1992/93	135	53	44	<1	0	0	<1	1
	1993/94	118	46	44	7	2	<1	0	0
	1994/95	163	43	44	7	2	2	2	0
	1995/96	96	56	33	3	5	2	0	0
	1996/97	176	44	43	10	2	1	0	0
	1997/98	139	58	29	6	3	1	2	0
	1998/99	115	52	36	5	3	3	0	0
	1999/00	145	48	38	11	2	1	0	0
	2000/01	150	43	47	7	1	2	0	0
	1991/01	**1,598**	**48**	**42**	**6**	**2**	**1**	**<1**	**<1**
NEC	1991/92	30	30	50	13	3	3	0	0
	1992/93	28	61	25	11	4	0	0	0
	1993/94	23	56	35	9	0	0	0	0
	1994/95	26	31	58	8	4	0	0	0
	1995/96	13	54	38	0	0	8	0	0
	1996/97	11	36	36	0	9	0	18	0
	1997/98	15	47	33	13	7	0	0	0
	1998/99	11	73	27	0	0	0	0	0
	1999/00	23	48	35	4	4	4	4	0
	2000/01	16	62	25	6	6	0	0	0
	1991/01	**196**	**48**	**38**	**8**	**4**	**1**	**1**	**0**
SEC	1991/92	393	82	14	1	2	<1	0	0
	1992/93	253	72	25	2	<1	<1	0	0
	1993/94	153	63	29	3	3	<1	<1	0
	1994/95	131	49	36	4	5	1	3	1
	1995/96	158	58	30	7	4	0	0	0
	1996/97	115	63	30	3	<1	3	0	0
	1997/98	194	39	44	7	4	<1	2	4
	1998/99	181	35	46	9	5	4	<1	0
	1999/00	213	56	26	11	5	<1	<1	<1
	2000/01	18	72	17	6	0	0	0	5
	1991/01	**1,809**	**61**	**29**	**5**	**3**	**1**	**<1**	**<1**
NWC	1991/92	23	65	22	0	4	4	4	0
	1992/93	45	38	51	4	4	2	0	0
	1993/94	11	73	9	0	0	0	0	18
	1994/95	19	63	21	5	0	5	0	5
	1995/96	15	67	20	7	0	7	0	0
	1996/97	23	48	35	8	9	0	0	0
	1997/98	25	60	24	4	0	8	0	4
	1998/99	16	75	25	0	0	0	0	0
	1999/00	22	59	32	4	0	0	4	0
	2000/01	11	82	9	9	0	0	0	0
	1991/01	**210**	**58**	**29**	**4**	**2**	**3**	**1**	**2**

continued

Region	Year	Fields	Electrical conductivity (mmhos/cm)						
			0-0.5	0.51-1.0	1.01-1.5	1.51-2.0	2.01-3.0	3.01-4.0	>4.0
SWC	1991/92	52	75	10	2	2	2	2	8
	1992/93	50	84	12	2	2	0	0	0
	1993/94	23	74	17	9	0	0	0	0
	1994/95	31	84	16	0	0	0	0	0
	1995/96	16	87	12	0	0	6	0	0
	1996/97	12	67	25	0	0	8	0	0
	1997/98	28	64	32	0	0	4	0	0
	1998/99	25	76	24	0	0	0	0	0
	1999/00	35	71	23	3	3	0	0	0
	2000/01	21	86	14	0	0	0	0	0
	1991/01	**293**	**77**	**17**	**2**	**0**	**0**	**0**	**0**
NW	1991/92	38	63	34	3	0	0	0	0
	1992/93	21	81	5	9	5	0	0	0
	1993/94	26	73	27	0	0	0	0	0
	1994/95	16	62	31	0	7	0	0	0
	1995/96	14	79	14	7	0	0	0	0
	1996/97	24	38	54	4	0	0	4	0
	1997/98	19	58	37	5	0	0	0	0
	1998/99	12	83	17	0	0	0	0	0
	1999/00	14	57	29	14	0	0	0	0
	2000/01	7	57	43	0	0	0	0	0
	1991/01	**191**	**64**	**30**	**4**	**1**	**0**	**<1**	**0**
SW	1991/92	41	58	27	7	2	5	0	0
	1992/93	33	45	39	9	3	0	0	3
	1993/94	70	69	14	11	6	0	0	0
	1994/95	70	39	57	1	0	3	0	0
	1995/96	22	41	27	14	9	0	0	0
	1996/97	39	49	23	20	3	5	0	0
	1997/98	24	79	8	8	4	0	0	0
	1998/99	20	65	15	15	5	0	0	0
	1999/00	40	55	20	12	7	5	0	0
	2000/01	71	66	27	6	0	1	0	0
	1991/01	**430**	**56**	**28**	**9**	**3**	**2**	**<1**	**<1**
Statewide	1991/92	965	63	30	3	2	<1	<1	<1
	1992/93	588	63	31	3	1	<1	<1	<1
	1993/94	436	59	30	6	3	<1	<1	<1
	1994/95	459	47	41	5	3	2	2	<1
	1995/96	337	59	29	6	4	1	<1	0
	1996/97	415	49	38	8	2	2	<1	<1
	1997/98	453	50	35	7	3	1	2	2
	1998/99	394	49	37	6	4	3	<1	0
	1999/00	503	54	30	10	4	1	<1	<1
	2000/01	311	54	36	6	1	1	<1	<1
	1991/01	**4,861**	**56**	**33**	**6**	**3**	**1**	**<1**	**<1**

Table 19. Soil organic matter categories by region, 1991-2001.

Region	Fields	Soil Organic Matter, %											
		0-1.0	1.1-2.0	2.1-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.1-4.5	4.5-5.0	5.1-5.5	5.6-6.0	6.1-7.0	>7.0
		% of fields											
N-RRV	217	0	0	3	7	11	18	18	17	14	6	4	3
S-RRV	3,930	<1	3	7	11	16	19	17	12	7	4	2	1
NEC	328	<1	<1	2	11	15	22	27	11	5	1	3	1
SEC	2,224	0	3	11	25	27	16	10	5	2	<1	<1	<1
NWC	589	0	4	11	25	25	15	10	6	2	1	<1	<1
SWC	879	0	2	3	7	20	32	19	9	4	1	<1	<1
NW	804	<1	9	30	31	19	7	2	1	<1	<1	<1	<1
SW	851	<1	3	11	30	23	13	8	4	3	1	1	1
Statewide	9,822	<1	3	10	18	20	18	14	8	5	2	1	<1

Summary

Soil testing by North Dakota farmers greatly increased through the mid-1970s and early 1980s. However, since then, the total number of soil samples received at the NDSU laboratory has leveled off and started to decline through the 1990s. Many samples today are analyzed by commercial soil testing laboratories providing services in the state.

More than 430,000 North Dakota soil samples have been analyzed by the North Dakota State University Soil Testing Laboratory since 1953. The results for nearly 50,000 North Dakota soil samples analyzed between 1991 and 2001 are included in this report.

Available nitrogen levels are variable and should be determined each year. Phosphorus levels are frequently low but do not change greatly regionally from year to year. Potassium, zinc, iron, copper and sulfur deficiencies are less common than N or P, but still can be found in certain soils in North Dakota. Numerous areas within the state have excessive soluble salts. The soil pH is, in general, alkaline in the east but becomes more acid in parts of western North Dakota.

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