

The average cropped field tested in September and October from 1975-1978 had 58 lb of NO₃-N in the top 2 feet of soil while the average fallow had 108 lb, or 50 lb more than the cropped fields. The amount of accumulation for a particular field can vary from practically nothing to much more than 50 lb depending on previous crop, fertilization, weather, etc.

As shown in Table 4 the accumulation of NO₃-N is less in western North Dakota than in eastern North Dakota. The 54 lb of NO₃-N that accumulates on the average in eastern North Dakota would be adequate to grow 25 bu per acre of wheat while the 38 lb that accumulate on the average in western North Dakota would be adequate for 20 bu per acre yield in a year with ideal weather. Under a system of continuous cropping the amount of NO₃-N released would be less because of less soil aeration and frequent periods when soil moisture would be near the permanent wilting point.

Table 4. Average accumulation of NO₃-N on summer fallowed fields from 1975-78 in four areas of North Dakota.*

Area	1975	1976	1977	1978	Average
	lb NO ₃ -N per acre - 2'				
Red River Valley	45	57	48	64	54
East Central	49	48	53	53	51
West Central	50	47	24	41	40
Western	38	43	25	44	38

*Data based on results of NDSU Soil Testing Laboratory analyses of farmer's submitted soil samples.

In general it can be concluded that most soils in North Dakota do not release adequate amounts of available nitrogen for optimum crop production. The NO₃-N soil test can be used to determine the amount of available nitrogen in your fields and thus is a good method to determine the amount of nitrogen you may need to add for optimum crop production.

REFERENCES

1. Allison, F. E. 1973. *Soil Organic Matter and Its Role in Crop Production*. Elsevier Scientific Publishing Co., Amsterdam.
2. Buckman, Harry O. and Nyle C. Brady. 1974. *The Nature and Properties of Soils 8th Edition*. The MacMillan Co., New York.
3. Bartholomew, W. V. 1965. *Mineralization and Immobilization of Nitrogen in the Decomposition of Plant and Animal Residues*. pp. 285-306. In W. V. Bartholomew and Francis E. Clark (ed.) *Soil Nitrogen* American Society of Agronomy, Madison.
4. Haas, H. J., C. E. Evans and E. F. Miles. 1957. *Nitrogen and Carbon Changes in Great Plains Soils as Influenced by Cropping and Soil Treatments*. USDA Tech. Bull. No. 1164.
5. Jenny, Hans. 1941. *Factors of Soil Formation*. McGraw-Hill, New York.
6. Russell, E. Walter. 1961. *Soil Conditions and Plant Growth 9th Edition*. Longmans, Green and Co. Ltd., London.
7. Stevenson, F. J. 1965. *Origin and Distribution of Nitrogen in Soil*. pp. 1-42. In W. V. Bartholomew and Francis E. Clark (ed.) *Soil Nitrogen*. American Society of Agronomy, Madison.
8. Swenson, L. J., W. C. Dahnke and D. D. Patterson. 1979. *Nitrate-Nitrogen Accumulation and Movement in Some North Dakota Soils Under Dryland Conditions*. North Dakota Farm Research Vol. 36, No. 5:3-8.

The Use of Anhydrous Ammonia in North Dakota

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Use of anhydrous ammonia as a fertilizer in the United States was somewhat of a novelty until 1948. Consumption was limited from 1948 to 1954, partly because of shortages of the fertilizer and of steel for tank manufacture. However, the growth of the ammonia industry during the past 25 years has been phenomenal. Anhydrous ammonia use in North Dakota compared to that nationally, and especially that in a major corn-growing state such as Iowa, lagged noticeably until about 1970. As shown in Table 1, however, the relative importance of anhydrous NH₃ to the nitrogen-fertilizer industry in North Dakota during 1978 greatly exceeded the national figure and was on par with that for Iowa.

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The reason for the increased consumption of ammonia in North Dakota is primarily one of economics. Anhydrous ammonia (82-0-0), which is the most highly concentrated nitrogen fertilizer available, is now a much cheaper form of N than the competitive solids, urea (45-0-0) and ammonium nitrate (34-0-0). Anhydrous ammonia normally must be added 5 or 6 inches below the surface to prevent gaseous losses of ammonia. North Dakota farmers are increasingly saving time and money by combining application of ammonia with another tillage operation. Consequently, various pieces of tillage equipment have been modified to include attachments for ammonia application. Nurse tanks rather than special applicator tanks traverse North Dakota fields.

Table 1. Comparison of anhydrous ammonia-N (NH₃-N) usage in North Dakota with that in Iowa and the United States for the period 1955 through 1978¹.

Year	North Dakota		Iowa		United States	
	NH ₃ -N tons	% of total	NH ₃ -N tons	% of total	NH ₃ -N tons	% of total
1955	110	2.4	14,663	21.0	290,018	14.8
1960	2,456	12.0	25,573	24.8	581,214	21.2
1965	987	3.7	148,890	47.1	1,281,968	27.6
1970	7,504	10.4	427,702	64.8	2,844,058	38.1
1975	57,522	40.9	415,679	55.7	3,294,494	38.3
1976	95,497	47.5	602,689	57.8	4,047,220	38.9
1977	109,454	47.8	482,608	56.6	4,040,529	37.9
1978	155,085	61.3	536,575	58.3	3,721,288	37.3

¹ Material used in this table was obtained from published information provided by TVA (5).

While the short-term picture is bright, the availability of cheap, abundant quantities of anhydrous ammonia in the long term cannot be predicted with any confidence. Approximately 34,500 cubic feet of natural gas are needed to make a ton of anhydrous ammonia. Firms manufacturing ammonia in the United States which pay \$2.00 - \$3.00 per 1,000 cubic feet for natural gas are facing very severe financial difficulties. Many are operating below capacity and some have gone completely out of production. The end result has been that the United States is now importing large quantities of ammonia for agricultural use. Increased supplies of cheap imported ammonia almost certainly are keeping down prices of the locally produced product.

Will the supply of readily available anhydrous ammonia at reasonable or cheap prices continue? The question cannot be answered with certainty, but such factors as conclusion of an agreement between the USA and Mexico for natural gas sales to this country, the world-energy picture, the continuation of agricultural sales to, and the importation of ammonia from the Soviet Union, a favorable ruling from Federal tariff authorities that imported ammonia is not being dumped on the market in violation of the laws of the United States, and the strength of the dollar on world currency markets should influence the future course of events.

Important Properties of Ammonia

A knowledge of certain physical and chemical properties of ammonia is essential for safe and efficient use of anhydrous ammonia as a fertilizer. A summary of these pertinent data is given in Table 2. Anhydrous ammonia is transported as a liquid under considerable pressure.

Anhydrous ammonia in the liquid form will produce severe burns when it comes in contact with tissue. If it is inhaled as a gas, damage to mucous tissue of mouth, throat, nose and lungs may be serious (7). The fact that anhydrous ammonia boils at -28°F at atmospheric pressure means that ammonia will turn instantly into a gas if released into the atmosphere; as a gas it can travel quickly over considerable distances and cause severe damage. Unfortunately, accidents associated with overturned or damaged rail and road tank cars and nurse tanks, faulty regulators, use of poorly maintained equipment, incorrect use of equipment, and failure to use proper safety gloves and goggles are not rare events. In addition, many accidents would have been

Table 2. Selected physical properties of ammonia¹.

Characteristic	Value
Weight per gallon	
60°F	5.14 pounds
34.6°F	5.32 pounds
Solubility in water	
32°F	0.899 pound/pound H ₂ O
60.8°F	0.578 pound/pound H ₂ O
Vapor pressure	
30°F	51.6 pounds/inch ²
60°F	92.9 pounds/inch ²
100°F	197.2 pounds/inch ²
Specific volume	
30°F	0.02503 feet ³ /pound
60°F	0.02597 feet ³ /pound
100°F	0.02747 feet ³ /pound
Boiling point (760 mm)	-28°F

¹ Data for this table were obtained from published information by Sharp (7).

less serious if recommendations concerning the ready availability of a supply of water had been followed. New users of anhydrous ammonia should receive adequate instruction concerning the correct handling of this material.

Because of the pressure which builds up in tanks and hoses, all equipment associated with ammonia storage and use should be in excellent condition. Pressure regulators, tanks, valves and transfer hoses need to be inspected frequently. A preventative maintenance program for ammonia equipment is highly desirable (4). Movement of nurse tanks on public and private roads should be done at moderate speeds.

Data given in Table 2 indicate that considerable pressure may build up in hoses linking the nurse-tank valve and the regulator when equipment is left outside on hot sunny days. These hoses particularly must be maintained in good condition.

Anhydrous ammonia nurse tanks have safety valves which prevent them being filled beyond 85% of capacity.

Without this safety factor, extreme pressures could build up within tanks due to increases in specific volumes associated with increases in temperature.

While anhydrous ammonia does not attack common metals, moist ammonia will react with copper and zinc (7). These two metals or their alloys, thus, should not be used on equipment which comes in contact with ammonia. Aluminum-float gauges are attacked by N-serve-treated anhydrous ammonia. Therefore, stainless steel float gauges should be used in nurse tanks to which the chemical is added to suppress nitrification of ammonia in the soil.

Rate and Uniformity of Distribution of Applied Ammonia

Experience of farmers suggests that equipment used in North Dakota is reasonably effective at applying the required quantity of ammonia to a given area. However, applicators in which there is an appreciable drop in ammonia pressure between the tank outlet valve and the regulator, or between the manifold and the injection outlets may give anomalous application rates during cold periods (2). This sometimes may be a problem under North Dakota conditions. Accumulation of debris in a regulator's strainer may also affect ammonia-delivery rates. Strainers thus should be inspected and cleaned at regular intervals.

Very little information is available pertaining to lateral distribution of anhydrous ammonia by the various outlets on an application unit. Andrews et al. (1) indicated that trash in manifold orifices, rough orifices, non-uniform orifice sizes, and non-uniform size of applicator outlets cause irregularity in ammonia application. Pressure-regulator type metering devices combined with a radial distributor or manifold reportedly give uniform distribution of ammonia, provided hoses from the manifold to the applicator shanks are approximately the same length (6).

Some manufacturers suggest that equal-length hoses are not necessary if the pressure of ammonia within the manifold be increased to 10 pounds per square inch during application. Use of flow-equalizer manifold sleeves (3), which fit inside the manifold, or of manifold hose connectors with desired orifices are two ways for attaining this pressure. One manufacturer will soon be making available for the American market a manifold with easily adjustable orifice sizes.

Agronomic Efficiency of Anhydrous Ammonia

Anhydrous ammonia is a safe effective nitrogen fertilizer when properly applied. The Cooperative Extension Service of North Dakota State University recently released a circular (8) discussing agronomic aspects of ammonia use; readers are referred to this publication for additional information on that topic. The present writer has used anhydrous ammonia for four years in corn-fertility studies at Oakes. As indicated by the data in Table 3, anhydrous

ammonia greatly increased corn yields and was a very effective nitrogen fertilizer. The soil had a cation-exchange capacity of 15 meq per 100 g and had a pH of 8.0.

Table 3. Influence of application of 120 pounds of spring-applied anhydrous ammonia-N on irrigated corn production at Oakes.

Year	Anhydrous NH ₃ -N, lb/A		LSD (P=0.05)
	0	120	
	Corn, bushels/acre ¹		
1976	93	161	15
1977	115	189	13
1978	65	163	12

¹ Corn-grain yields are expressed on a 15.5% moisture basis.

SUMMARY

Anhydrous ammonia is now the dominant fertilizer used in North Dakota. Considerable care is needed to avoid accidents while using this fertilizer. Anhydrous ammonia properly applied is an effective fertilizer for use in North Dakota. Problems concerning lateral distribution of ammonia among injection outlets are discussed.

REFERENCES

1. Andrews, W. B., F. E. Edwards, and J. G. Hammons. 1948. *Ammonia as a source of nitrogen*. Mississippi Agr. Exp. Sta. Bull. 451.
2. Anonymous. 1977. *Guide for the accurate metering of anhydrous ammonia in cold weather*. John Blue Company, Huntsville, Alabama.
3. Anonymous. 1978. *Chart for determining ammonia flow equalizer orifice diameters*. Form ID60 479, John Blue Company, Huntsville, Alabama.
4. Anonymous. 1978. *Practical maintenance program for ammonia nurse tanks*. Fertilizer Progress 9(1):20,23,30.
5. Hargett, N. L. and J. T. Berry. 1979. *1978 fertilizer summary data*. Bull. Y-138 Tennessee Valley Authority, Muscle Shoals, Alabama.
6. Leavitt, F. H. 1965. *Agricultural ammonia equipment development and history*. pp. 125-142. In M. H. McVickar (ed.) *Agricultural anhydrous ammonia technology and use*. Agricultural Ammonia Institute, Memphis, Tenn.
7. Sharp, Joe C. 1965. *Properties of ammonia*. pp. 21-31. In M. H. McVickar (ed.) *Agricultural anhydrous ammonia technology and use*. Agricultural Ammonia Institute, Memphis, Tenn.
8. Wagner, R. C. and E. H. Vasey. 1979. *Anhydrous ammonia-its use*. Circular S-F-661, Cooperative Extension Service, North Dakota State University.