Use of Anhydrous Ammonia as a Nitrogen Fertilizer

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Crops require more nitrogen than any other plant food taken from the soil. The approximate nitrogen requirements of certain crops are as follows:

	Nitrogen
100-bushel corn crop, grain, and stover	150 pounds
25-bushel wheat crop, grain, and straw	43 pounds
1,800-pound burley tobacco crop, leaf, and stalk	100 pounds
1-ton legume hay	40-50 pounds

Nonlegume crops obtain their nitrogen mainly from organic matter in the soil, or from nitrogen applied in fertilizers. Legumes, however, through the bacteria in the nodules on their roots, obtain most of their nitrogen from the atmosphere. Much of this legume-fixed nitrogen is available to nonlegume plants growing with the legumes and, with good care and use of crop residues and farm manure, to nonlegume crops grown later. On farms where much of the land is in legume or mixed legume-grass crops, most of the nitrogen needed for crop growth should be provided in this way. With less use of legume or mixed legume-grass crops there will be more need for nitrogen fertilizers for good crop production. In general, fertilizer nitrogen should be used in any soil-crop situation where it is estimated that value of the immediate crop increase will exceed the cost of the fertilizer.

Increased Crop Yields from Nitrogen

On soils needing nitrogen, but with enough other plant food and moisture, the following crop-yield increases may be expected, within the low-to-moderately-high crop-yield range, for each pound of nitrogen applied:

Corn	⅓ to ½ bushel
Small grains	⅓ to ¼ bushel
Burley tobacco	5 to 6 pounds
Grass hay crops	30 to 40 pounds

For nitrogen fertilizers to pay, adequate phosphorus and potassium must be available for good crop growth. Use of nitrogen does not do away with the need for these other plant foods. It is more expensive to supply nitrogen in fertilizers for crops than to supply potassium and phosphorus, and nitrogen should therefore not be used when its effect is held down by their absence.

Chemical soil tests furnish useful information as to need for phosphorus and potassium.

Common Nitrogen Fertilizers

The chief nitrogen fertilizers are listed below, the figures indicating the amount of fertilizer containing approximately 50 pounds of nitrogen:

Nitrogen fertilizer	*Amount containing 50 lb nitrogen*
Ammonium nitrate	150 lb
Sodium nitrate	300 lb
Ammonium sulfate	250 lb
Calcium cyanamide	250 lb
Urea	114 lb
Anhydrous ammonia	60 lb
Nitrogen solutions	125-250 lb

Nitrogen fertilizers differ somewhat in their availability to crops, in their tendency to leach from the soil, and in their residual effect in increasing or decreasing soil acidity; but, in general, all are about equally effective when applied on the equivalent nitrogen basis.

Two of the fertilizers in the list above are mainly obtained from accumulated natural sources—sodium nitrate from natural deposits in Chile, South America, and ammonium sulfate from coal as a byproduct of the coking of coal. The other nitrogen fertilizers are made by chemically fixing nitrogen from the atmosphere. The principal process now in use is to cause one part of nitrogen (N) and three parts of hydrogen (H) to combine to form ammonia (NH_3).

Ammonium nitrate, the most extensively used nitrogen fertilizer at the present time for direct application, is made by first producing nitric acid from a certain amount of ammonia and then causing this acid to react chemically with another equal amount of ammonia. Because of this additional operation, on the equivalent nitrogen basis, the manufacturing cost of ammonium nitrate is considerably greater than the cost of ammonia.

Anhydrous Ammonia

At ordinary temperatures and at atmospheric pressure, ammonia is a gas. It is quite soluble in water, such solutions containing 20 to 30 percent ammonia. By pressure, ammonia gas is condensed to a liquid and then is designated anhydrous ammonia (ammonia without water to distinguish it from the water solution). At a temperature of 50° F., anhydrous ammonia has a gauge pressure of 75 pounds per square inch, and at 100° F., 197 pounds. It contains 82 percent nitrogen.

With proper machinery, anhydrous ammonia can be applied to the soil for fertilizer purposes. Its use in this way started in Mississippi in 1947 and quickly spread to other states. Rapid increase of its use for fertilizer has been due to the cheaper cost of nitrogen at the manufacturing plant and to the scarcity of solid forms of nitrogen.

Soil chemically absorbs ammonia; hence, once it is in the soil, ammonia is not lost to the atmosphere, or easily leached from the soil so long as it remains in this form. Obviously, however, anhydrous ammonia, when released from the applicator tank under pressure, changes to a gas and must be placed in the soil and be well covered with the soil to prevent loss of the gas to the atmosphere. In the soil, ammonia (NH_3) picks up another hydrogen (H) and becomes ammonium (NH_4). Ammonium is the form of nitrogen in ammonium sulfate.

Ammonium to Nitrate in the Soil

Some crop plants use ammonium nitrogen fairly well, but most crops use nitrate nitrogen much more readily. The soil microbes, however, change ammonium to nitrate. This process is rapid in warm weather, slower in cool weather, and practically ceases during the winter. Applied early in the spring, the nitrogen in anhydrous ammonia thus is less available to crops than the nitrate half of the nitrogen in ammonium nitrate, or the nitrogen in sodium nitrate, all of which is in the nitrate form. After the weather warms up, however, and during the growing season proper, the change of ammonium to nitrate is rapid enough for the two forms to be about equally available to crops.

Nitrate nitrogen is not chemically held by the soil as is ammonium and hence is much more subject to leaching from the soil. There is very little leaching of soluble nitrogen from Kentucky soils after the first of April, even in the absence of a crop on the land, so that practically neither form leaches during the growing season. All nitrate nitrogen, however, leaches from the soil in Kentucky during the winter, mainly in January, February, and March. Hence anhydrous ammonia can be applied to the soil in the late fall or winter with but little danger of leaching-loss, whereas nitrate nitrogen cannot. However, if anhydrous ammonia is applied early in the fall, the soil microbes change it to nitrate during warm weather and it then will leach from the soil.

To keep anhydrous ammonia from being lost to the atmosphere, it must be applied deep in the soil (4 inches or more). This means that in dry seasons the fertilizer will be in moist soil, and hence more available to the crop than solid nitrogen fertilizers such as ammonium nitrate applied in the surface soil. This, however, is not a very important point in most years, and the difference does not exist when the two forms are applied equally deep.

The ammonium form of nitrogen thus has an advantage for application in the late fall or winter because it does not leach to any great extent. The nitrate form, however, is better for application in the early spring, because it is more readily available to plants. In general, however, as stated before, all the nitrogen fertilizers are about equally effective when properly applied and when applied at rates to give equal amounts of nitrogen. An important consideration in their purchase is the relative cost of the nitrogen in the different fertilizers, including cost of application.

Applying Anhydrous Ammonia

Anhydrous ammonia often is applied as a side dressing on row crops during early growth. The fertilizer usually is applied midway between the rows. Roots of the plants soon reach the nitrogen and take it up. It may be desirable, however, at planting

or setting to apply at the row a fertilizer containing some nitrogen to increase early growth of the plants.

When anhydrous ammonia is applied before planting or setting row crops, or in pastures or small grain fields, it appears to be satisfactory for the applicators to be spaced no closer than 30 inches.

Anhydrous Ammonia Applicators

Anhydrous ammonia to be used as a fertilizer is stored as liquid under pressure in a tank. As it changes into gas at atmospheric pressure when released, it must be placed in the soil at a depth of 4 inches or more, with the furrow-opening closed to prevent loss of the gas to the atmosphere.

Two types of anhydrous ammonia applicators or machines have been developed in recent years that have proven practical. One is called the trailer-mounted machine, to be drawn behind a tractor, and the other the tractor-mounted. (See Fig. 1 and 2.)

Each type of machine consists of a frame mounting a 100- to 150-gallon tank equipped with a filler valve, a liquid depth gauge, a 300-pound pressure gauge, a relief or safety valve set to open at 250 pounds pressure, a tank bleeder valve, a valve in discharge

Fig. 1.— A tractor-mounted anhydrous ammonia applicator equipped with a pump-type metering device and five spring-tine mounted applicators.

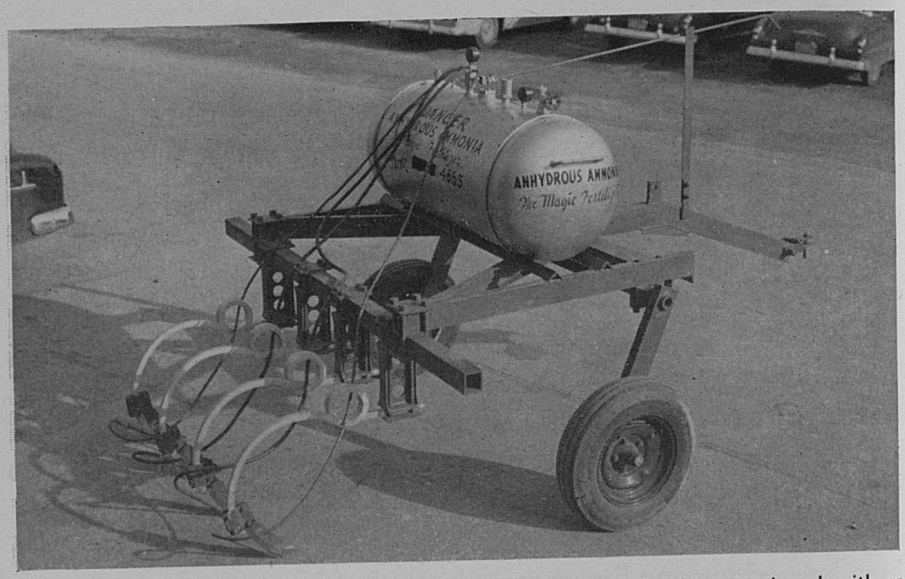

Fig. 2.— A trailer-mounted anhydrous ammonia applicator machine equipped with an automatically regulated metering device and four spring-tine applicators.

pipe, distribution and meter valves, or a metering pump and distribution hose lines and soil penetrating devices called applicators for placing the ammonia in the soil at the proper spacing and desired depth. Under certain soil conditions, a sealer or covering device in the form of a wheel or drag hoe should be attached to the rear of each applicator to prevent loss of ammonia gas into the air.

The tank and all the valves, pipes, fittings, and metering devices and gauges must be designed to meet the American Society of Mechanical Engineers standards of strength and State regulations. They must be made of steel. Brass, bronze, aluminum, and galvanized surfaces corrode in the presence of ammonia.

Metering Equipment

The metering of anhydrous ammonia so as to apply it into the soil at uniform rates was a difficult problem for the designers to solve because the pressure in the tank varies as the temperature of air changes during the day, and the pressure decreases as the ammonia is discharged from the tank.

There are two types of metering devices on the market that have proven to be satisfactory. An automatic differential pres-

sure metering device, such as is used on a liquified petroleum gas tank, may be used. (See Fig. 3.)

This device must be made of materials that will not be injured by ammonia. Tests have shown that this type of regulator valve can be adjusted for accuracy to within 1 percent if used within the capacity of the valve. This metering or regulating device must be checked and adjusted according to instructions and charts furnished by the manufacturer, assuring that the correct amount of nitrogen is applied per acre.

The charts show the pressure settings for the gauge or regulator for the output openings for various rates of application of ammonia per 100 feet of travel, or per acre for different numbers and sizes of openings, width of implement, and different tractor speeds in miles per hour. The regulator can be set in the morning according to the charts and will not have to be reset during the day, regardless of the tank pressure.

The second type of metering device is a plunger-type pump provided with an adjustment for varying the length of stroke to vary the amount of ammonia discharged per acre. (See Fig. 1.)

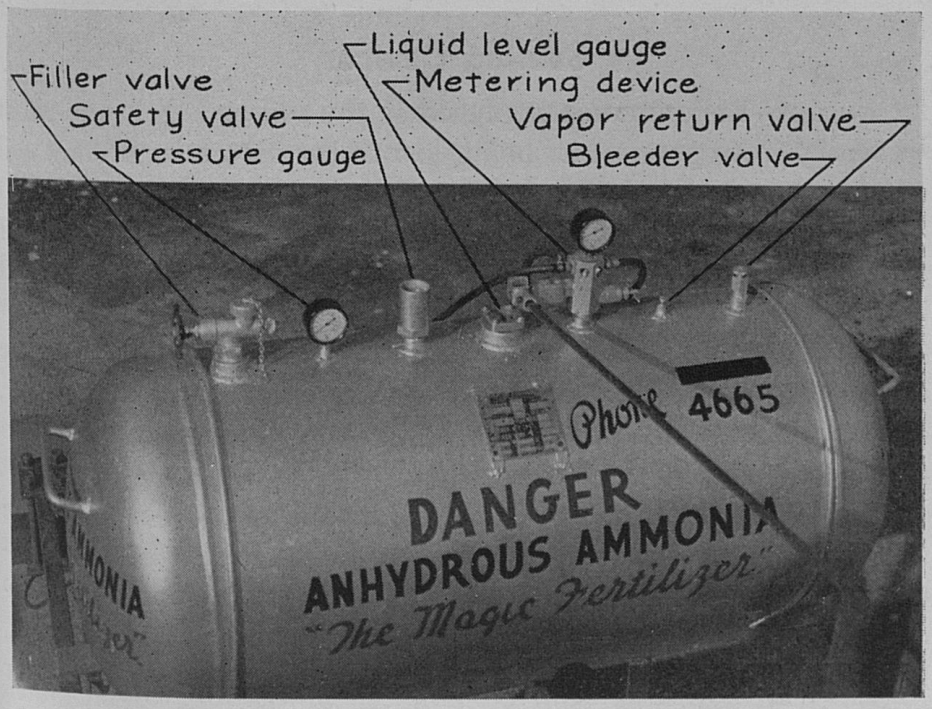

Fig. 3.— A supply tank equipped with an automatically controlled metering device.

This metering device has the advantage that the speed of the tractor does not affect the amount of ammonia applied per acre, and the flow of ammonia is automatically stopped when the tractor stops. The pump is equipped with a heat exchanger to prevent the liquid ammonia from vaporizing in the pump. As a small amount of wear around the plunger rod or leaky valves in the pump will cause this unit to become inaccurate, the pump should be repaired before the start of each season.

Types of Applicator Chisels or Blades

The applicators for placing the anhydrous ammonia in the soil at a depth of not less than 4 inches are classified as follows:

(1) Spring tine, the spring being part of drag bar (Fig. 4).
(2) Spring trip, a compression type of spring mounted in a cylinder to allow chisel to rise out of ground if a rock is struck (Fig. 5).
(3) Spring trip applicator equipped with a plain blade or cutaway rolling coulter mounted in front of chisel and wheel furrow sealer (Fig. 5).

The applicators are so mounted that their number and the space between them can be changed. Some outfits are designed to use as many as eight applicators, depending on spacing desired.

Sealing Devices

Because the ammonia is placed in the soil as a gas, and must be sealed in to prevent its being lost to the air under certain soil conditions, a sealer is needed.

When applying anhydrous ammonia in sod, the wheel or sliding sealing device should be used. Either one may be attached to the rear of the applicator shank.

In cultivated land, a cultivator shovel or disc hiller can be used. They should be set ½ the depth of the applicator blade, and so placed that the dirt will be crowded against the blade to completely seal in the ammonia.

Under favorable soil conditions, the soil closes readily on the applicator blade and the ammonia combines with the clay particles and moisture so rapidly that a sealing device is not required. It is easy to tell when anhydrous ammonia is escaping, for if it is escaping a white vapor will be seen rising at the rear of the applicator from the cut in the soil.

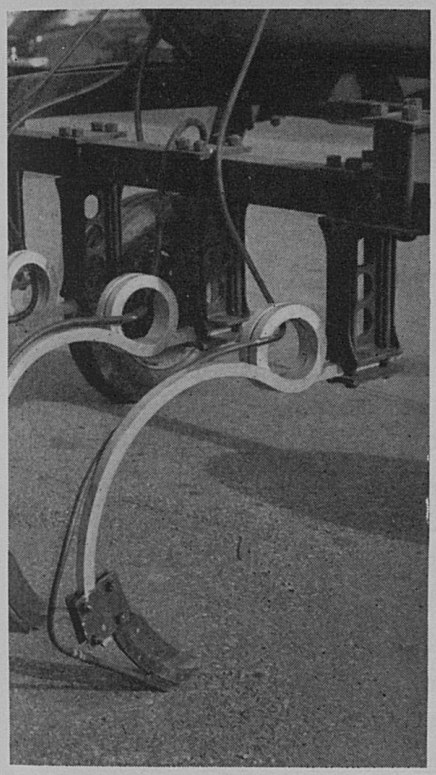

Fig. 4.— Details of a spring tine, the mounting of the applicator or chisel, and the hose and discharge nozzle for conducting the ammonia from tank to bottom of furrow.

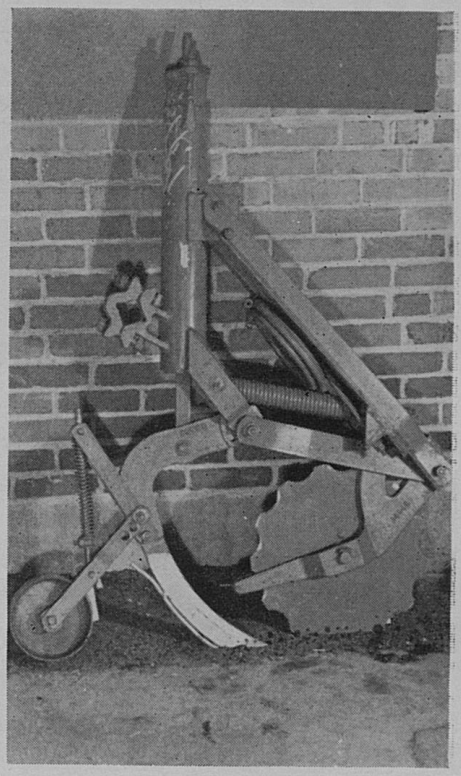

Fig. 5.— A spring-tip mounted applicator equipped with a cutaway disc and a wheel for sealing furrow opening.

Size of Tractor Required

The amount of power or size of tractor required to operate one of these distributors depends upon the soil conditions, the number of applicator chisels used, and the depth applied. Tractors having a rating of 25 to 35 belt-horsepower are commonly used.

The trailer type can be hitched to any tractor of the correct horsepower. The tractor-mounted type requires the manufacturer to furnish special equipment for mounting the machine on different makes and models of tractors. Most distributors of this type of equipment are glad to give farmers the necessary instructions for mounting and operating their machines.

Safety and Operation Precautions

During the past three years, large quantities of anhydrous ammonia have been safely handled by men who had no previous

experience in handling it. However, there are certain safety regulations or precautions that must be followed in storing, transporting, and applying it. The distributor of the anhydrous ammonia should be able to give you the information you will need.

One should not be careless about handling anhydrous ammonia because it can have very disagreeable reactions, causing irritation of the eyes, skin, nose, throat, and lungs. High concentrations may burn, blind, strangle, or cause death. Ammonia vapors will kill germinating seeds and leaves on direct contact.

Do not leave the valves on the transport tank or field applicator tank open to outside air, and do not fill tank with water, propane gas, or any material other than anhydrous ammonia. Between seasons, keep a small amount of ammonia in the tanks. When setting the metering devices, be sure that you follow the instructions furnished by the manufacturer and use the correct tables for the size of nozzles you have on your machine.

When operating the machine, check the gauges on the tank and applicator nozzles frequently to see if the applicator is applying the anhydrous ammonia correctly.

Costs Involved

A farmer can lease equipment, buy his own equipment, or arrange for a custom operator to apply anhydrous ammonia for him. Charges made by custom applicators are generally based on a fixed fee per acre (varies with acreage covered) plus the price of the anhydrous ammonia.

Farmers are becoming increasingly interested in the use of anhydrous ammonia for fertilizer. About 700 tons were used in Kentucky last year. The Experiment Station staff has not been in a position to gather any cost data from farmers. Farmers, therefore, should contact local commercial operators regarding cost of ammonia and of applying it.

By using the information on page 4 of this publication and local prices, the cost of nitrogen in the different nitrogen fertilizers can be calculated.

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