XII Some Factors Influencing Choice of Nitrogen Fertilizers

Introduction

The usual aim in choosing which nitrogen fertilizer or fertilizers should be produced and marketed is, or should be, to determine which products will produce the greatest increase in crop value per dollar spent. The problem is not a simple one; it involves estimation of the cost of manufacturing or procuring the products, the cost of marketing and distributing them, the agronomic effectiveness of the alternative products, and the value of the increased agricultural production. The answer may be different for different crops or regions. Often some compromise must be made between cost of manufacture and distribution on the one hand and agronomic effectiveness on the other. The question, whether to supply nitrogen in two or more forms to meet diverse needs, needs to be considered in light of whether the additional benefit is worth the additional cost (if any). Finally, a decision is needed as to whether only straight nitrogen fertilizers should be produced or whether nitrogen should also be produced in the form of compound fertilizers. Most countries have found it useful to supply both types.

Agronomic Considerations

Ammoniacal fertilizers as a group have some characteristics in common. Most plants cannot utilize ammoniacal nitrogen effectively (rice is a notable exception), thus for most crops utilization is dependent on conversion of the ammoniacal nitrogen to nitrate nitrogen in the soil. This conversion takes place through a series of microbiological processes and is usually quite rapid in warm soils. However, the reaction requires oxygen and cannot take place when air is excluded from the soil as, for example, by flooding. The rate of nitrification decreases as the soil temperature decreases, and at soil temperatures of $10^\circ C$ and below, nitrification practically ceases. For this reason fertilizers containing at least some nitrate are preferred for use in cold climates for those crops that make substantial growth in early spring when soil temperatures are low. Many farmers have found it useful to supply both types of nitrogen, depending on the type of fertilizer, pH of soil, temperature, etc. Anhydrous ammonia would volatilize instantly if applied to the soil surface, thus it must be injected 10 cm or more below the surface to avoid heavy losses. The same is true of aque ammonia of the usual concentration (25% NH$_3$). Dilute aque ammonia (5% NH$_3$) can be surface applied without serious losses on some soils. Surface-applied urea may be subject to moderate to heavy losses, particularly in warm, humid climates or on calcareous soils. In the case of flooded rice, loss of ammonia by surface application of urea depends on the pH of the floodwater rather than that of the soil. When urea is

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1. When an ammoniacal fertilizer is placed in the reducing (anaerobic) zone of a flooded soil, it remains in the ammoniacal form and hence resistant to leaching as long as the zone remains anaerobic. Since the rice plant can utilize ammoniacal nitrogen efficiently, this situation provides an important opportunity for rice farmers to minimize nitrogen losses by leaching or volatilization.

2. Since ammoniacal nitrogen does not nitrify in cold soil, it may be applied in late autumn for fertilization of crops to be planted in the spring without danger of loss by leaching during the winter in those climates where the soil temperature remains below $10^\circ C$ during the winter. This situation enables farmers to take advantage of a low price or abundant supply of fertilizer which may be available during the autumn and to apply the fertilizer during a less busy time than the spring planting season.

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applied to the surface of unflooded soil, ammonia loss depends on the rate of hydrolysis of urea to ammonia and carbon dioxide and can be largely prevented by working it into the soil soon after application or by timely rains or irrigation.

Ammonium bicarbonate is subject to serious loss of ammonia unless it is worked into the soil. Other ammonium salts are relatively free from ammonia loss problems; however, appreciable loss can occur with surface application on strongly alkaline soils or from surface floodwater, especially with diammonium phosphate and even with ammonium sulfate.

All ammoniacal fertilizers are acid forming, but ammonium sulfate and chloride are the most strongly acid forming since both the nitrogen and the anion contribute to acidifying the soil. (For a discussion of the acid- and base-forming characteristics of fertilizers, see Chapter XXI.) The acid-forming quality may be an advantage for use on alkaline soils or for crops that require acid soils (such as tea). In other cases the acidity is likely to be a disadvantage since eventually the soil may become so acid as to be unfit for agricultural use unless corrected by application of limestone.

The value of the anion of the ammonium salt must be considered. This is especially true of ammonium phosphates which are usually considered as phosphate fertilizers, since their N:P$_2$O$_5$ weight ratio ranges from 1:5 for MAP to 2.5 for DAP. However, there are considerable economic advantages of utilizing a substantial amount of nitrogen, as will be pointed out in Chapter XVII, and should be given due consideration in planning a nitrogen supply. Ammonium sulfate is often valued for its sulfur content since there are widespread deficiencies of this element (see Chapter XX). However, its S:N ratio is far greater than needed for most situations, thus it is often used as an ingredient of compound fertilizers rather than as a straight nitrogen fertilizer. The chlorine content of ammonium chloride is beneficial in rare cases (see Chapter VIII) but more often deleterious for some crops and soils. It leaches rapidly from watered soils and is not considered harmful in most cases except for specific crops that are sensitive to it or situations where chloride accumulations in the soil present a problem (such as semiarid soils).

Nitrates are generally agronomically effective and preferable for some crops (tobacco) or for rapid response in cool soils. Nitrates leach readily from some soils under conditions of heavy rainfall or irrigation. Nitrates are, of course, free from ammonia loss problems. In flooded or waterlogged soils, nitrate nitrogen may be reduced ("denitrified") first to nitrite then to N$_2$, N$_2$O, or NO and thus lost to the atmosphere. For this reason, nitrates are generally regarded as unsuitable for subsurface application to flooded rice.

Sodium, calcium, and potassium nitrates have a basic reaction in the soil which is an advantage for acid soils. The sodium content of sodium nitrate may be useful in increasing yields of certain crops, but it may be a disadvantage for soils that already have an excessive sodium content. Calcium nitrate finds use on saline soils since the calcium will replace sodium adsorbed on clay, permitting sodium to be washed out. The main disadvantage of calcium and sodium nitrates is their low analysis (15%-16%). Potassium nitrate is generally considered as a potash fertilizer (13-0-44), and its advantages will be discussed in Chapter XVIII. However, it is also valued for its nitrate nitrogen content for use in some specialty fertilizers, such as tobacco fertilizer.

Ammonium nitrate contains both ammoniacal and nitrate nitrogen in equal amounts and therefore has some of the advantages and disadvantages of both forms. It is generally regarded as agronomically effective for a wide range of crops and soils with the notable exception of subsurface application on flooded rice. It is satisfactory for use on upland rice and in some cases for surface application on flooded rice. It is widely used in Europe and North America both as a straight nitrogen material and as an ingredient of compound fertilizers. The urea ammonium nitrate solution (UAN) and ammonium sulfate nitrate (ASN) contain one-quarter of their nitrogen in the nitrate form and three-quarters in the ammoniacal form.

Physical Properties and Safety

The physical properties of fertilizers are an important consideration and sometimes a deciding factor. The physical properties of solid fertilizers will be discussed in Chapter XXII and in various other chapters dealing with specific products. Chapter X covered pertinent physical properties of nitrogen solutions, anhydrous ammonia, and aqua ammonia.

Some hazards are involved in storage, transportation, and use of ammonium nitrate and some compound fertilizers containing it, which were discussed in Chapter VIII. In some countries where safe practices are difficult to enforce, these hazards could be a serious drawback. Likewise transportation, storage, and usage of solid ammonium nitrate would involve hazards (Chapter X) which can be reduced to an acceptable level only by enforcement of rigid specifications for the equipment and following safe practices. These conditions may be difficult to attain in some countries.

Manufacturing Considerations

The choice of nitrogen fertilizer to be produced within a country may be influenced by linkages with other industries or by the resources of the country. The manufacture of urea is not economical except when associated with an ammonia plant. For countries where importation of ammonia would be less expensive than indigenous production, a good choice could be use of imported ammonia for production of ammonium nitrate, ammonium phosphate, ammonium sulfate, or some combination of the three. Another possibility for using imported ammonia is production of nitrophosphate fertilizers, which would supply both nitrogen and phosphate fertilizers. In most cases it is better to plan the fertilizer industry as a whole rather than the nitrogen industry separately.

Ammonium sulfate is often available as a byproduct from other industries, such as coking operations, metallurgical extraction processes, and caprolactam production; low-cost byproduct sulfuric acid for use in making ammonium sulfate may be available from smelting industries. Also ammonium sulfate may be a convenient byproduct from pollution abatement facilities. Likewise, ammonium chloride may be produced economically as a coproduct of soda ash production or from byproduct hydrochloric acid from other industries.

Conversely, fertilizer production facilities often can supply raw materials for other industries; ammonia and urea have many industrial uses, and ammonium nitrate is widely used as a blasting agent in mining industries or in road building. Therefore, integrated planning of the industrial sector may influence the choice of nitrogen fertilizer products.

Economic Considerations

The usual aim in choosing a nitrogen fertilizer is to select a product or products that will result in the lowest average delivered cost per kilogram of N at the