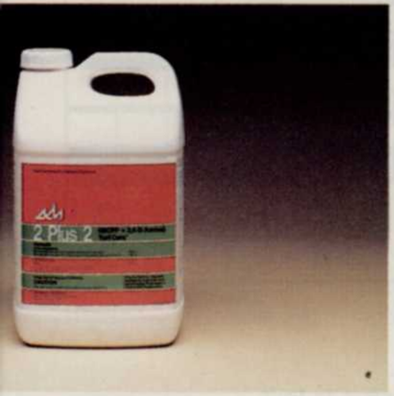
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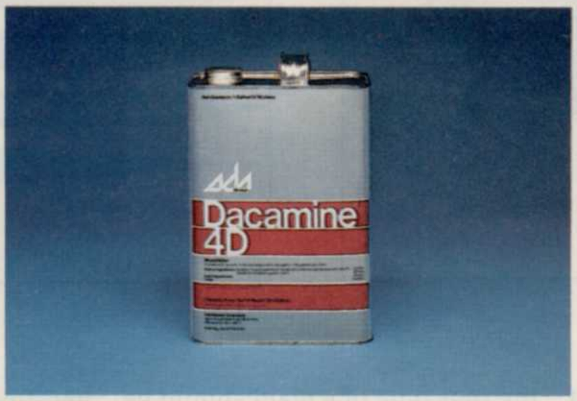
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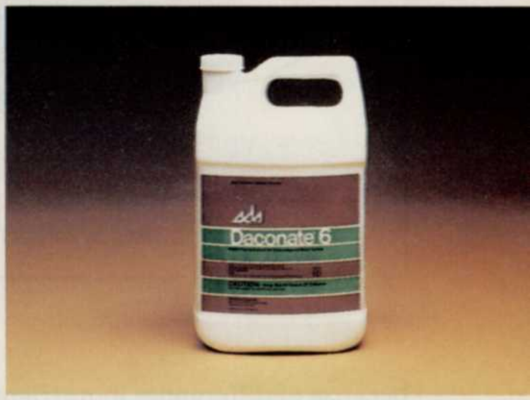
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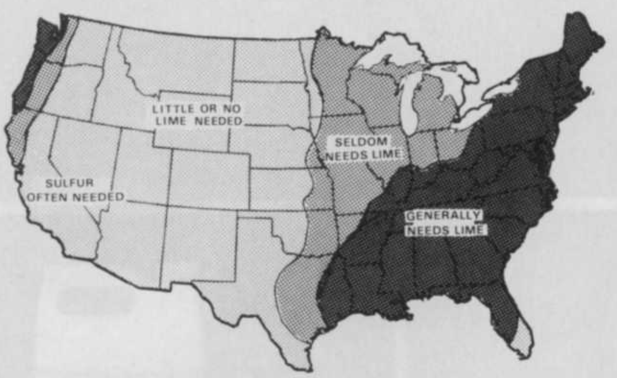
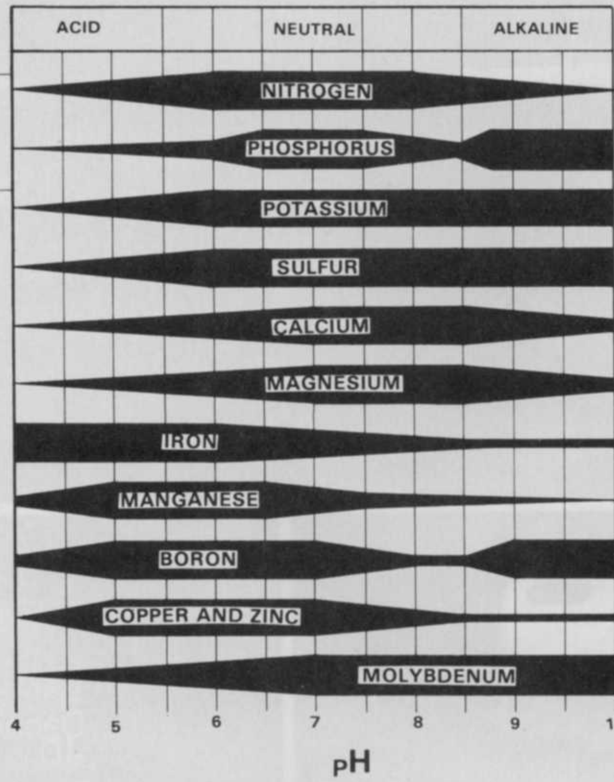
Fertilizer



Geographic trends *in soil pH amendment.*



because of differences in nutrient requirements. For most plants, a pH of 6.5 fits the availability of most nutrients, without toxic amounts of any nutrient.

However, certain plants—such as rhododendrons, azaleas, pines and camellias—require comparatively large amounts of nutrients that are soluble in acid solution. They are "acid-loving" plants and grow best in soils of pH 5.5.

Soil acidity, as such, is seldom toxic to plants, but below pH 5.5 certain elements such as aluminum and manganese may become soluble to levels toxic to plant growth.

It has also been shown that pH levels affect the rate of of thatch decomposition, since they influence the organisms which break down thatch.

In some cases, nutrient availability can be improved by correction of the soil pH as well as by supplemental fertilization. Sulfur and agricultural lime are the materials used most frequently to alter the soil reaction or pH.

Lime increases the pH (decreases acidity); sulfur lowers the pH (increases acidity).

Ideally, the pH of soil within the root zone of a plant should be measured every three to five years and, if necessary, adjusted to the most favorable range for that particular species. Unfortunately, lowering the pH of an alkaline soil is not always succesful, particularly if the soil is inherently calcareous with significant calcium reserves.

Leaching

Leaching is the removal of materials in solution from the root zone. Leaching is caused by percolation, the lateral and downward movement of water through soil. Loss of nutrients due to leaching is proportional to the amount of water percolated through the soil. Water dissolves minute quantities of mineral and organic matter. Soil and weather conditions affect leaching.

All nutrients are subject to leaching, but not to the same degree. Calcium losses are the greatest of any nutrient known. Nitrate salt—the form of nitrogen primarily absorbed by plant roots—moves with ground water and rapidly leaches from the root zone. Magnesium, sulfur and potassium are moderately leached, whereas only a trace of phosphorus is lost.

Primary Fertilizer Elements

Nitrogen, phosphorus and potassium are the three nutrients required in the greatest quantity from the soil. In addition to these, iron is most likely to be found deficient in soils. Soil and tissue analysis can be used to determine the deficiency of any nutrient.

Nitrogen

Nitrogen is required in larger amounts than other elements supplied by the soil. Compounds formed by the plant from nitrogen comprise up to 50 percent of the dry weight of the plant. Nitrogen is a component of proteins, chlorophyll, amino acids and enzymes.

Nitrogen is more often deficient in soils than any of the other essential nutrients.

Plants can absorb nitrogen as either the ammonium (NH4+) or nitrate (NO3-). Urea or inorganic forms of nitrogen are converted to ammonium which is subject to volatilization when surface applied. More than 25 percent can be lost to volatilization under certain conditions.The ammonium form of nitrogen may be taken up

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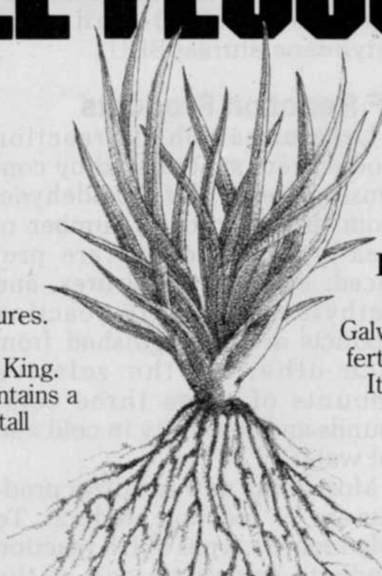

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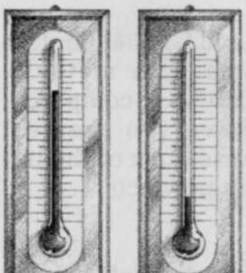

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by plant roots or transformed to nitrate which is the form most nitrogen is absorbed by plants.

Since nitrate ions are negatively charged, they are not absorbed by soil colloids (negatively charged) and readily move with soil water. Thus, heavy rainfall or irrigation may move nitrate below the root zone.

Because of the transitory nature of nitrogen in mineral soils, soil analysis is not as useful in determining deficiencies as an observation of symptoms. Nitrogen deficiencies are observed as uniformly yellowish-green leaves or needles which are more pronounced in older tissue. Leaves are small, thin and may start dying at the tips. The growth rate is reduced.

Nitrogen sources used for horticultural fertilization are often categorized as quick-release or controlled-release, based upon the rate nitrogen becomes available to the plant.

Controlled-Release

Controlled-release nitrogen sources include both slowly soluble nitrogen, which is an inherent characteristic of the fertilizer, and slow-release nitrogen which is imparted to a soluble fertilizer by an artificial coating.

In general, both types cost more per unit of nitrogen than quick-release sources and provide the following advantages: gradual supply of nitrogen which reduces the number of necessary applications, reduced leaching and reduced volatilization, and lower risk of burning which allows higher application rates.

Slowly Soluble

Slowly soluble nitrogen sources release nitrogen as their chemical structure slowly breaks down. Both natural and synthetic organic fertilizers can be classified as slowly soluble and are broken down by hydrolysis and/or microbial activity into soluble forms of nitrogen.

Natural organics include sewage sludge and plant and animal wastes, generally low in nutrient content.

Because of the bulk required to provide sufficient nutrients, and storage and odor problems, natural organics are being replaced by synthetic organic nitrogen in many fertilization programs. The most common synthetic organic nitrogen sources are ureaformaldehyde(UF) and isobutylidene diurea(IBDU).

> Soil analysis is not as useful in finding nitrogen deficiencies as observing symptoms.

UF Reaction Products

Ureaformaldehyde reaction products are synthesized by condensing urea with formaldehyde. From this reaction a number of urea-type compounds are produced; urea, methylol urea, and methylene urea. UF reaction products are distinguished from each other by the relative amounts of these three compounds and solubility in cold and hot water.

Most of the new fertilizer products are UF reaction products. To help identify types of UF reaction products scientists look at the number of carbon lengths in the chemical chain which results from condensing urea with formaldehyde.

Solubility of UF reaction products decreases, along with nitrogen release and burn potential, as the number of carbon lengths increase. Urea contains the least number of carbon lengths and methylene urea contains the largest number. Methylol ureas fall in between.

Ureaformaldehyde(Nitroform), a product of BFC Chemicals, Inc., contains at least 35 percent nitrogen, mostly in insoluble and slowly soluble forms. At least 60 percent of the total nitrogen of UF is insoluble in cold water.

Hawkeye's Formolene and Georgia Pacific's GP4341 are two liquid products which contain soluble methylol urea as the UF compound. C.P. Chemical's Nitro-26 Plus is also a liquid, but methylene urea is the predominant urea compound. Cleary's Fluf is a flowable liquid(a liquid containing microfine particles) which contains methylene urea as the predominant UF compound. Scott's Polyform is a homogeneous granular form of methylene ureas.

Knowledge of the relative amounts of urea, methylol urea, and methylene urea contained in liquid UF reaction products can be used as a guide in predicting their potential to cause fertilizer burn.

Fluf would have the least burn potential because it contains less than 16 percent urea with methylene urea as the predominant UF compound and 20 percent of the total nitrogen is water insoluble.

Nitro-26 Plus, like Fluf, also contains less than 16 percent urea with methylene urea as the major UF compound. However, Nitro-26 Plus contains no water insoluble nitrogen and therefore could be considered intermediate in burn potential.

Formolene and GP4341 contain 50 percent urea with methylol urea as the primary UF compound and would have the greatest potential to cause burn of the liquid UF reaction products.

IBDU

Isobutylidene diurea(IBDU) is produced by reacting urea with isobutyraldehyde and is marketed in two size ranges, fine (0.5-1.0 mm) and coarse (0.7-2.5 mm). Urea is released from IBDU through the hydrolytic action of water.

Factors which increase the rate of nitrogen release from IBDU include: 1) decreasing particle size, 2) increasing soil moisture, 3) increasing soil temperature,

and 4) increasing soil acidity (lowering pH).

IBDU (Par-Ex) is sold by Estech General Chemical Corp. and contains 31 percent nitrogen which is 85 to 90 percent insoluble, depending upon particle size.

Slow-Release

Slow-release nitrogen is produced by encapsulating quick-release nitrogen with an insoluble coating. The soluble nitrogen is released through tiny pores as the coating is broken down in the soil. A mixture of variable coating thicknesses provides continuous release of soluble nitrogen for a controlled period of time. Only two slow-release nitrogen sources are commercially available—sulfur coated urea and Osmocote.

Sulfur-Coated Urea

Sulfur-coated urea is produced by coating urea with molten sulfur and then sealing the granule with oil or wax. The soluble nitrogen is released through tiny pores or imperfections in the coating.No two particles are coated the same.

The nitrogen release rate or dissolution rate is determined by placing sulfur-coated urea in water at 100 degrees F. for a seven-day period and is expressed as percent dissolved at the end of that time. Most SCU products have a dissolution rate between 20 and 30 percent. Factors which increase the release rate of nitrogen from SCU include: increasing soil temperature and increasing soil moisture.

Sulfur-coated urea is commercially available with 32 to 37 percent nitrogen from Canadian Industries Ltd., AG Industries Mfg. Corp.(a subsidiary of Lakeshore Equipment and Supply Co.), and O.M. Scott.

Osmocote

Osmocote is manufactured by encapsulating soluble fertilizer with a plastic, semiporous coating. Water enters the capsule, dissolves the nutrients, and then diffuses out into the soil for plant uptake. Osmocote is marketed by the Sierra Chemical Corp.

Quick Release

Quick-release nitrogen sources are all soluble in water and are either available for root uptake in their present form or are readily converted to available forms in the soil. Inorganic nitrogen fertilizers (do not contain carbon) such as ammonium nitrate and ammonium sulfate are quick-release. Urea, although technically an organic source of nitrogen, is soluble and possesses many of the same characteristics as the inorganics. Organic doesn't always mean slow-release.

> FAN's nitrogen release is similar to urea, but its burn potential is much lower.

In general, the quickly available nitrogen sources are less expensive than controlled-release sources and have the following characteristics: 1) readily soluble in water, 2) immediately available for absorption, 3) can cause growth flushes, 4) short soil residual, 5) leach and/or volatilize, and 6) high burn potential,

Recent developments in ureaformaldehyde reaction products have provided quick-release nitrogen with a burn potential much lower than for other soluble nitrogen sources.

New Products

A newcomer to the soluble nitrogen market is avaible from the W.A. Cleary Co. as a liquid product under the name FAN. FAN contains 20 percent nitrogen and is produced by reacting urea and acid aldehyde to form ethylidene urea. Although the nitrogen release rate is similar to that of urea, the burn potential is much lower. The markets for FAN should be the same as for the sprayable UF reaction products.

Melamine (triaminotriazine) is a relatively new controlled-release nitrogen source produced by Melamine Chemicals, Inc. Melamine is combined with urea in 1/3(urea):2/3(melamine ratio by weight. It is marketed under the trade name Super 60, which has a 60-0-0 analysis.

Super 60 is currently sold for forest and rice fertilization and is being tested for the nursery and tree and turf care industries. It has a possible application in both the granular and liquid fertilizer markets since the granules disburse in water releasing urea into solution, while the melamine powder remains in suspension.

Melamine is very slowly broken down in the soil with an initial lag of more than 60 days before nitrification, followed by controlled release of nitrogen for a period of one to two years. Depending upon the results of further laboratory and field studies, melamine and/or various combination products may be available in the near future as an alternative to UF, IBDU, and SCU.

Phosphorus

Phosphorus is especially important in seedling growth. It is utilized in carbohydrate conversions, energy transfer, and is a component of nucleoproteins and phospholipids. Phosphorus helps maintain a desirable pH in cells and contributes to root development.

Phosphorus deficiencies are most often encountered in seedlings. Leaves or needles turn a dull green becoming reddish-bronze to purple, especially along margins in cold weather.

Some Phosphorus is provided by soil minerals and soil organic matter but it is very slowly available from these sources. Since phosphorus moves very little through soil, supplemental phosphorus tends to accumulate near the application site, moving only a few inches in 50 years.

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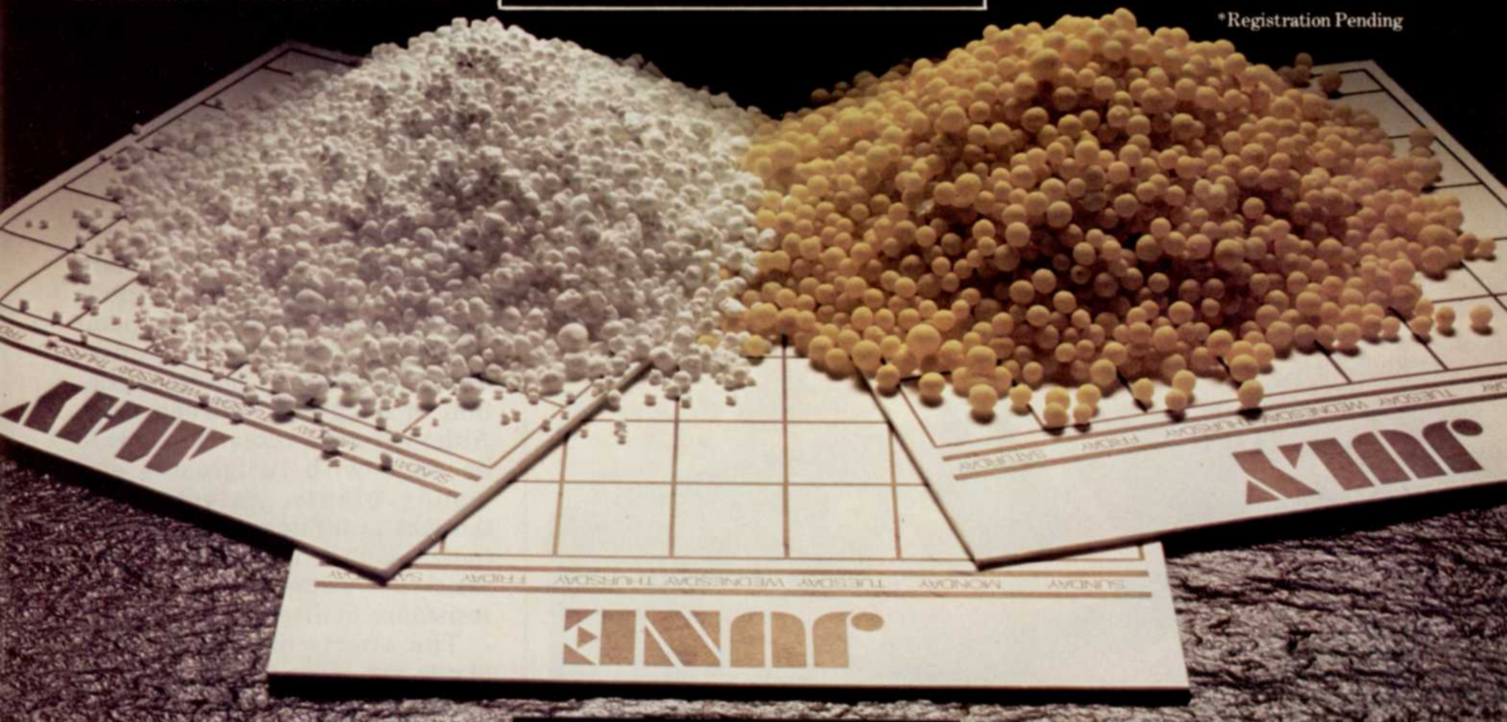

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Fertilizer

Plants take up phosphorus primarily in the orthophosphate form (H_2PO_4-). Although soils normally contain relatively large amounts of phosphorus, much of it is in forms not available to plants.

Phosphorus availabilty is influenced by soil pH. At a pH below 5.5, iron and aluminum form an insoluble complex with phosphorus that is not available to plants. At a pH above 7.5, calcium combines with phosphorus to form insoluble compounds such as calcium phosphate. Phosphorus is most available between pH 6.0 and 7.0.

The most common phosphorus sources for granular application are the superphosphates with a P_2O_5 equivalent of 20 to 48 percent.

Soluble phosphorus sources include monoammonium phosphate (11-48-0), recommended for alkaline soils, and diammonium phosphate (18-46-0).

Liquid ammonium phosphate (10-34-0) is often used where bulk tank storage is feasible. Monopotassium phosphate (0-52-34), a soluble, granular product, has an excellent potential as fertilizer because of its high analysis and low salt index. High cost of production has limited its use.

Potassium

Potassium is found in all plant parts in relatively large quantities and functions in catalyzing plant reactions, regulating transpiration, and aiding in the translocation of materials between cells. Although more research needs to be done with turfgrasses and woody plants, potassium is thought to influence rooting and increase heat, cold and drought resistance as well as enhancing resistance to disease.

The effects of potassium on plants are more subtle than the effects of nitrogen because they are not normally expressed visually in terms of growth rate or leaf color. Potassium deficiencies may restrict the translocation of car-