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SOLUBILITY, UPTAKE AND LEACHING OF NITROGEN AND POTASH

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It is most fitting that this panel discussion on plant nutrients concern itself first with Nitrogen and Potash. These two elements are the nutrients used by plants in the greatest amounts. Both are mobile within the plant and in many ways complement each other in their roles in the plant metabolism. When either is available in insufficient amounts the rate of plant growth is quickly reduced.

NITROGEN

Nitrogen largely controls the growth and reproductive cycle in most plants. It is quite mobile and enters into many compounds. When other elements are not limiting, nitrogen largely controls the use of carbohydrates within the plant and determines whether growth shall be vegetative or reproductive. When nitrogen is in good supply, the plant tends to continue vegetative development. But when N is used up carbohydrates accumulate and the physiology of the plant is shifted toward the reproductive cycle.

Nitrogen has a marked influence on the quality and value of plants used by man. Deficiency of N results in reduced chlorophyll. The leaves become light green or yellow-green, later followed by drying and the dropping of old leaves.

Of the nitrogen found in the soil, 95% occurs in organic forms, which from a practical standpoint are unavailable to plants. Nitrogen which is immediately important to plants is in the ammoniacal and nitrate forms. Nitrogen becomes immobilized when it is incorporated into organic compounds, plant tissues or microorganisms.

Soil organic matter is broken down by microbial action and organic nitrogen is converted into mineral forms (mineralization). This process liberates ammoniacal nitrogen first. Afterward, mainly by bacterial action, ammonia is oxidized into nitrite and nitrate nitrogen. The immobilization and mineralization processes depend a great deal on the carbon:nitrogen ratio of the organic matter. When the ratio is high, nitrogen is in short supply and microorganisms will use nitrates and ammonia from the soil. When the ratio drops, as when nitrogen fertilizer is added to the soil, mineralization takes place.

Uptake of nitrogen by the plant is largely from the nitrate ions in the soil solution. However, there is evidence that roots can absorb ammonium ions by direct contact of the roots with the soil media where the ammonium ions are held.

Fixation of nitrogen (and potassium) reaches its maximum in soils high in expanding (2:1) type clays with large amounts of illite. Ammonium and potash ions may become entrapped in the lattices and held firmly by electrostatic forces.

Leaching of nitrogen takes place with the movement of water through the soil carrying with it dissolved nutrients. Nitrogen losses are largely in the nitrate form. This problem is greatest in sandy soils or areas of high rainfall. Leaching is less in soils with high exchange capacities. Ammoniacal forms of nitrogen are less subject to leaching because some of it is temporarily fixed. The soils which have a higher organic matter content and greater exchange capacity are less subject to leaching.

Common Forms of Nitrogen Fertilizer

	N	P_2O_5	K_2O
Ammonium sulfate	20.5		
Ammonium nitrate	32.5		
Mono ammonium phosphate	11.0	48.0	
Calcium nitrate	15.5		
Potassium nitrate	13.4		44.2
Sodium nitrate	16.0		
Urea	46.0		

Ammonium fertilizers applied to alkaline surfaces or calcareous soils. Some ammonia gas will be volatilized.

Urea hydrolizes to ammonium carbonate very quickly when added to soil. The latter is unstable and decomposes to CO_e and NH_4^+. Urea-fertilizer grade may contain amounts of biuret which is toxic and can injure plants if too high. For certain crops (LB) "low biuret should be specified, for foliar applications to citrus Biuret content should not exceed 0.25% soil applications lemons and navel oranges of urea containing up to 2.5% biuret did no 'lasting injury' ". Pineapple leaves were injured by applications containing 3% Biuret.

Slow release fertilizers which have come on the market recently, offer solutions to certain problems. Their use in potting mixes makes it easier to maintain nursery plants. However, the cost factor may preclude their use in the field at least for the present.

POTASH

Potassium makes up about 2.5 percent of the earth's crust. It occurs mostly in the form of crystal lattices. It is found in the soil in mica, felspar and clay minerals. When micas and felspars weather they release potassium slowly. Natural potassium in the soil or that added as fertilizer which becomes bound so that it cannot be replaced by a neutral salt is called "fixed potassium". Fixation is rapid, half of it taking place in a few hours. Fixation is related to the amount of K added to the soil. Acidity seems to decrease fixation.

The exchangeable K is the portion absorbed by clay and organic soil particles from which it can be displaced by other neutral salt cations or by hydrogen ions. Organic matter plays a greater role than clay particles in holding exchangeable K. Plant roots take up this absorbed K either by contact exchange or after the adsorbed cation passes into the soil solution. The change from exchangeable K into soil solution is very fast. The change of K from exchangeable to fixed takes place fairly fast but the change from fixed K to exchangeable K is very slow. If there is little K in the soil solution, the process of liberation from fixed K is intensified but still slow.

Although the relationship between K and nitrogen metabolism is not well understood, it is known that when K is limiting, the quantity of soluble nitrogenous compounds is increased and proteins are increased. It is also known that potassium is required in the synthesis of proteins.

Potassium is vitally important to the plant and is required in large amounts. Yet its functions in the plant are not yet fully understood. It is not combined with any organic groups of compounds in the plant cell. It is in solution in the cell sap or absorbed on the plasma. It is almost completely extracted with water from the plant tissues. It accumulates in the parts of the plant where cell division takes place. It can be pulled out of the older leaves when there is a shortage in the plant and transported to the young meristimatic tissues.

The main function of potassium is maintenance of the state of swelling of the plasma colloids necessary for all metabolic processes. By maintaining a balance between anabolism, respiration and transpiration, it keeps the water economy of the plant in equilibrium and reduces the tendency to wilting. It may be connected with promotion of carbon dioxide assimilation, the formation, condensation and transportation of sugars and the synthesis of fats. The absorption and reduction of nitrates, cell division and other processes are stimulated by an adequate supply of potash.

The injurious results of too much nitrogen can often, to a great extent, be corrected if the plants receive enough potash. A balanced ratio of N to K is important in plant nutrition. Potash contributes to the hardening of the support tissues of the plant (sclerenchyma tissues) which leads to better resistance to lodging. It has beneficial effects on fiber in fiber plants. In fruits, keeping quality is often improved and they become more resistant to fungus diseases by the hardening of tissues.

Potassium can exert a favorable effect on root development. Excess K can accentuate a deficiency of magnesium in perennial crops. Light soils are often low in potassium because it is so easily leached. In heavy soils leaching of potassium is small. If a soil is high in calcium it is often poor in K.

Potassium fertilizers are all soluble in water. The two most widely used forms are Muriate of Potash (KCl 50-52% K) and Sulfate of Potash (K_2SO_4 44% K). The muriate form is a little lower in price but it leaves a residue of chlorine ions which are toxic to some crops. Among these are citrus, pineapple, potatoes and tobacco. For these crops the sulfate form is recommended. Bananas which are heavy users of potash are not sensitive to chlorine and the muriate form can be used.

For crops growing in soils high in potassium fixing clay minerals, band applications give better results than when it is broadcast and mixed into the soil. The bands should be placed to the side and below seeds or young transplants to avoid fertilizer burn.

Leaching of both potash and nitrogen is most serious in coarse textured soils especially in areas of high rainfall. Liming acid soils can increase the exchangeable K a soil can hold. Losses of N and K can be somewhat reduced by applying fertilizer in smaller but more frequent amounts.