THE PLANT-SOIL COMPLEX WITH PARTICULAR REFERENCE TO SASKATCHEWAN CONDITIONS

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The major element requirements in plant nutrition are well known. In addition to the major elements added in commercial fertilizers, i.e. nitrogen, phosphorus and potassium, carbon, hydrogen and oxygen are major nutrient elements and actually make up most of the green or dry weight of the plant.

Carbon, hydrogen and oxygen are usually listed as available from the water and carbon dioxide of the plant environment, soil and atmosphere. Investigation of photosynthesis has shown that carbon dioxide supplies both carbon and oxygen and, of course, hydrogen is obtained from water. In many regions, but particularly in Saskatchewan, it is important to emphasize that water is a nutrient as well as part of the necessary medium for plant growth. It is important to remember that a comparatively small decrease in the water content of the plant results in a serious decrease and complete interruption of photosynthesis. Although we know that much of this result is due to the effect on cells as the plant wilts and other physiologic action, one might conjecture as to whether the actual condition of the water in the plant may not have some stereo-chemic effect on metabolism. It could even be that the beneficial effect of improved nutrient supply on efficiency of water use by the plant might be due to the effect on water chemistry in the plant as well as the apparent influence on resistance to wilting that may be noted in the field. A number of experiments have shown no increase in the total water used due to fertilizer application - although some work in the U.S.A. has shown decreased yields the following year apparently due to a decrease in residual moisture. Occasional decreases of this type have also been noted in Saskatchewan.

The occurrence of regular moisture deficits in Saskatchewan must be continually remembered when fertilizer use is considered. It is not good enough to glibly quote some experimental work to show that added fertilizer increases moisture efficiency. This is not universally true and does not constitute an economic basis for fertilizer use where moisture is in very short supply.

We need say very little about carbon dioxide supply. There has been conjecture that carbon dioxide could be the final limiting factor in nutrition for very high yields but there is little agreement on this and experimental data is not plentiful. One could say, however, that maintenance of high level of organic matter along with its pronounced influence on soil physical condition might contribute to an enhanced supplying power for carbon dioxide in the plant environment.

Of the three major nutrients usually supplied in commercial fertilizer we shall deal only briefly with nitrogen and phosphorus since these will be covered in detail in subsequent papers. It is only necessary to note that phosphorus is our most important nutrient in Saskatchewan - or for that matter generally. Very few soils supply sufficient phosphorus for maximum or optimum growth. Phosphorus is, however, subject to extreme variations in need from year to year and, of major importance, does appear to be the major nutrient in achieving early and uniform maturity. Nitrogen is probably still in the category stated in the first progress report of the former Soil Research Laboratory as "one of the last elements to become a limiting factor under dry land agriculture". This would not be so true for grey-wooded soils or dark grey soils in northern Saskatchewan. It is well to point out, too, that the use of legumes for maintenance of nitrogen levels is attractive in Saskatchewan because the generally high calcium status of our soils provides satisfactory soil conditions for legume establishment.

Potassium appears to be deficient only in very local areas of Saskatchewan. Extensive testing has actually shown a tendency for added potassium to reduce yields in many cases. Exchangeable or soluble potassium is generally much higher than in humid areas. One might question whether luxury supplies of potassium do not interfere with other element supply. To date strongly leached sandy soils and peat soils are generally the only types showing a response to potassium.

There is some interest in trying to project the potassium picture into the future. On the basis of experience in other regions, we might anticipate that three to four decades of optimum inputs of nitrogen and phosphorus could be used on most soils before potassium would become limiting. On some sandy soils of the northern part of Saskatchewan production of alfalfa or other high potassium demand crops for processing might hasten the time when potassium would be needed.

Lack of those elements which might be termed "secondary" in plant nutrition occurs in limited areas of Saskatchewan. Calcium and magnesium are generally in ample supply and there is still disagreement on the effect of the abundant supply of calcium in Saskatchewan soils. Calcium may be in short supply in certain horizons of solod or eluviated soils but generally, supply does not seem to be limiting enough to interfere with establishment of most plants.

Sulphur is important on grey-wooded soils of northern Saskatchewan. It is of particular importance for legume production and some response has been noted on cereals. Since sulphur is of importance in essential amino acid formation, sulphur has an important role in both yield and quality. There are also indications that inorganic sulphur content of plants may be of importance in animal nutrition.

Unavailability or deficiency of iron is well known in the so-called "lime-induced chlorosis" of shrubs and other plants. Iron was also the only trace element to show effect in some laboratory work done by the Department of Soil Science on soils from the Zealandia area a few years ago. The problem of iron deficiency is complex, affected by both soil and plant condition, and deficiency does show both species and variety effects.

Other trace elements have been given little attention and there is little evidence of widespread occurrence of shortages. Boron deficiency has been noted in alfalfa and as usual, seems to be closely related to pronounced moisture deficiency. Manganese deficiency has been noted locally resulting in "grey speck" disease of oats, and some local intensity in perosis or "slipped tendon" of poultry has been noted. Copper deficiency has been noted only in isolated cases of sub-critical levels in liver of lambs. Zinc has not yet been reported in Saskatchewan as a deficiency. From work in neighbouring states zinc is likely to be short first for potatoes or corn and heavy applications of phosphorus may aggravate any shortage. Zinc also is important in mineral nutrition of hogs in control of parakeratosis.

Of the other elements involved in either plant or animal nutrition we need say little. Sodium, chlorine and selenium may be present in phyto-toxic amounts or in amounts to cause animal nutrition problems. Molybdenum has been found in too large amounts in Manitoba and could be similarly present in Saskatchewan. Molybdenum toxicity is often due to interference with copper.

Saskatchewan soils, derived from a variety of rock material, youthful and subjected to very small leaching effects are generally reasonably well supplied with plant nutrient elements to obtain yields feasible under average moisture conditions. At the current moment it would seem that the supply of moderate amounts of available phosphorus, combined with similar amounts of nitrogen for stubble crops satisfies most of our needs. One might suggest that soil management for optimum moisture use and creation of a suitable plant environment are of first importance supported only (and necessarily) by the input of commericial fertilizer. It is erroneous in the extreme to treat all Saskatchewan soils as seriously deficient in fertility - this is true only for local areas because of inherent soil deficiency or accelerated erosion.

THE HOW AND WHY OF PHOSPHORUS

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A. Phosphorus in the Bag

Primary source of P - By far the most important source of P is rock phosphate with a chemical composition of $[Ca_3(PO_4)_2]_3 \cdot CaF_2$ (or $Ca(OH)_2$). In some parts of the world, particularly with acid soils this rock phosphate can be finely ground and used directly with some success. Most phosphate fertilizers used, however, are obtained through "processing" the rock phosphate.

Marketed forms - Most phosphate fertilizers commercially available today are either calcium or ammonium salts. By far the greatest world tonnage used is the calcium salt but for calcareous soils such as we have here in Saskatchewan, the ammonium salts appear to be better.

a. Monocalcium phosphate - $Ca(H_2PO_4)_2 \cdot H_2O$

The chemical reactions that probably take place in its production from rock phosphate and sulfuric acid are: