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PERSPECTIVES

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# PHOSPHATES & YOUR FUTURE

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## Introduction

Phosphate is an essential component of the human body and necessary in the human diet. The primary source in the human diet is from plants produced by intensive crop development in favorable agricultural areas around the world. Plant growth depletes the natural phosphorus content of the soils with time, and this depletion can be replaced by the addition of phosphate enriched fertilizers on a regular basis. Humans can live without gold, aluminum, diamonds and most mined metals, but they cannot live without food containing the essential elements necessary for life.

## Phosphorous

Phosphorus acts primarily as an"energizer" because of its role in converting the sun´s energy into food, fuel and fiber. Phosphorus plays a key role in photosynthesis, the metabolism of sugars, energy storage and transfer, cell division, cell enlargement and the transfer of genetic information.

Why is phosphorus important? Some of the benefits that phosphorus provides in growing plants are: improved root

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growth, earlier maturity of grain, higher crop yield, better water use efficiency and increase yields – all desirable attributes from a farmer´s perspective.

What nutrients do crops need? The nutrient uptake varies greatly among major agricultural crops. Corn and wheat are considered high phosphorus use crops while soybeans, rice and cotton are viewed more as heavy potassium users. The goal in sampling potential and existing crop area soils is to understand what the soil should provide to the crop and then apply the necessary fertilizer between the crop uptake needs and the amounts the soil will provide.

**Table 1** below shows the nutrient uptake by major crops.

| Crop | #N | #$P_2O_5$ | #$K_2O$ | #S |
|---|---|---|---|---|
| Corn (180 bu) | 240 | 100 | 240 | 28 |
| Soybeans (60 bu) | 325 | 65 | 140 | 25 |
| Wheat (55 bu) | 120 | 45 | 85 | 13 |
| Rice (7500 lbs) | 120 | 60 | 170 | 12 |
| Cotton (1500 lbs) | 180 | 65 | 155 | 40 |

| Days | % of Total Use | Total % |
|---|---|---|
| 0-25 | 4 | 4 |
| 26-50 | 27 | 31 |
| 51-75 | 36 | 67 |
| 76-100 | 25 | 92 |
| 101-125 | 8 | 100 |

**Table 2:** P2O5 Usage by 180-Bushel Corn Crop

When does the corn plant need phosphorus? A 180-bushel corn crop requires 100 pounds of P2O5. Approximately 30% of the total phosphorus is taken up by the plants in the first 50 days. Unlike potassium, phosphorus is required in larger quantities through maturity. Shortly before pollination, corn plants remove over 3 pounds of P2O5 per acre per day. P2O5 usage by 180-bushel corn crop is shown in Table 2 (below). Phosphorus deficiency in corn has the following symptoms: twisted ears or irregular kernel rows, purple or reddish color on lower leaves and stems, overall stunted plants, and delayed silking.

## Importance of Balanced Nutrition

Nitrogen is critical for growth, but the nitrate form is very mobile in the soil, and can move into ground and surface water. In corn, without phosphorus fertilizers added, the addition of more nitrogen fertilizer can dramatically increase soil nitrate. In contrast, where phosphorus fertilizers were added, the corn crop utilized the additional nitrogen added and soil nitrate levels only increased moderately with increases in nitrogen. At the optimum rate of nitrogen for corn, adding phosphorus reduced soil nitrate levels by 66%.

Adequate phosphorus is necessary for higher yields and improved grain quality. The amount of phosphate fertilizer required is dependent on existing soil test levels. The critical level of phosphorus in the soil is approximately 20 ppm. Yield losses can be severe as the soil phosphorus levels drop below 20 ppm. As an example, a field testing 10 ppm that did not receive phosphorus fertilizer would be expected to yield 80%of a field that was above the critical level. It requires approximately 18 pounds of P2O5 to raise soil test levels 1 ppm. Phosphate, a primary constituent of fertilizer, is generally mined using open pit methods – the standard both in Idaho and in Florida, the two primary phosphate producing areas of the United States. Due to the competitive nature of the fertilizer market, the mining of phosphate is particularly sensitive to production economics. Phosphate ore represents as much as 20-30% of the cost of fertilizer. Therefore, the costs to extract and deliver the ore represent a major portion of the total cost to produce fertilizer, and American mining studies have shown that equipment maintenance represents 30-40%of the mine's total operating costs.

Phosphorus is one of the 92 naturally occurring elements in the Periodic Table of Elements. In the natural world phosphorus is never encountered in its pure form, but only as phosphates, which consists of a phosphorous atom bonded to four oxygen atoms. This can exist as the negatively charged phosphate ion (PO43'), which is how it occurs in minerals, or as organophosphates in which there are organic molecules attached to one, two or three of the oxygen atoms.

In mineable form it is typically found in phosphate rocks, those containing variable amounts of phosphorus, typically in minerals with the chemical formula Ca5(PO4, $CO_3$)3 (F.OH, Cl). The phosphate rock is the most important source of phosphorus and this rock was mined for a total of 172 Million tonnes in world production in 2010. Phosphate rock is typically very fine grained, and the phosphate mineral is one of the members of the fluorapatite-chlorapatite-hydroxylapatite series. The major constituents in apatite are CaO - 50 to 55%, and P2O5- 38 to 42%. The term collophane is used for the cryptocrystalline variety of apatite. Rock phosphate grades are quoted as percent P2O3 or as percent TPL or percent BPL (Tri-Phosphate of Lime or Bone Phosphate of Lime, equivalent to 2.185 x percent P2O5).

Sales of phosphate rock are generally by annual contract with consumers, with minimum grades about 30% P2O5 (about 66% TPL). This means that a 6% P2O5 phosphate rock will need to be upgraded by a factor of 5 times to make a saleable product. Premium prices are often given for high grade concentrates with a chemical analysis in the range of 32.5 to 35%P2O5 (70 to 77% TPL). Penalties are applicable to phosphate rock with significant content of sulfuric acid consuming minerals, such as free calcium carbonate, iron oxides and alumina. The presence of a wide variety of metals and halogens (particularly fluorine) above minimal level is undesirable.

Over 85% of the total phosphate mined in the world is used for fertilizer products, either as direct application product or in the manufacture of upgraded products.

## Phosphate Rock Sources

The average igneous rock has a phosphorus content of 900 ppm. A 6% P2O5 phosphate rock would contain 60,000 ppm of

the P2O5 molecule, demonstrating the significant enrichment of phosphorus needed to make a potentially economically mineable deposit. Potentially mineable phosphate rock sources can be igneous, sedimentary, metamorphic, secondary weathering enrichment and any other combination of geologic rock types, so they are widespread over the entire earth. For many years, the highest grade phosphorite deposits were mined on the island of Nauru in the Pacific Ocean where the guano deposits formed by the excrement of sea birds on desert coasts, composed of limestones, made for direct shipping ores of 37.9% P2O5. The growth and development of agricultural crops leads to a natural degradation of the phosphate, potassium and nitrogen content of the soils in which the crops are grown. In some parts of the world these depletion rates are higher than in other parts of the world which leads to some inequities in the demand and consumption of fertilizers on a global basis.

Potassium Chloride (MOP) is another important basic product. The mixture of these products, in turn, leads the granulations and the NPK (Nitrogen-Phosphorus-Potassium) formulations, also known as complex fertilizers.

## World Fertilizers Market

The world consumption of fertilizers is around 160 million tonnes of nutrients, annually. In 2009, estimates of the International Fertilizer Industry Association (IFA) show a drop in demand of these inputs because of the downturn in the global economy that has affected agriculture in many countries. In 2010, the fertilizer association expects a rise of around 5% in the world demand of those inputs that may reach a volume of 165.8 million tonnes.

| | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Sold or Used by Producers | 31,100 | 28,900 | 25,500 | 28,100 | 28,500 |
| Consumption | 33,800 | 31,600 | 27,500 | 30,500 | 31,800 |
| Price, average value, dollars per ton, f.o.b. mine | 51.1 | 76.76 | 127.19 | 78.5 | 94 |

**Table 3:** United States Production of Phosphate Rock (in thousand metric tons)

## Current Supply and Demand for Fertilizers

In the fertilizer chain of production, the mineral-extraction segment supplies the basic inputs for production of the raw materials. Of the raw materials -phosphate rock, sulphur and ammonia - are required to produce intermediate products: nitric, sulphuric and phosphoric acids, which combined together form the basic fertilizers, among which the most important are MAP, DAP, SSP and urea.

| | Mine Production | |
|---|---|---|
| | 2010 | 2011 |
| China | 68,000 | 72,000 |
| United States | 25,800 | 28,400 |
| Morocco and Western Sahara | 25,800 | 27,000 |
| Russia | 11,000 | 11,000 |
| Canada | 5,700 | 6,200 |
| Jordan | 6,000 | 6,200 |
| Egypt | 6,000 | 6,000 |
| Tunisia | 7,600 | 5,000 |
| Syria | 3,000 | 3,100 |
| Australia | 2,600 | 2,700 |

**Table 4:** Top Ten World Producers of Phosphate Rock (in thousand metric tons)

In the medium term, the consumption of nutrients should reach 187 million tonnes, being 111 million tonnes of nitrogen, 44 million tonnes of P2O5 and 31.4 million tonnes of K2O. World phosphate rock capacity is projected at 248 million tonnes in 2013, representing an overall 30% growth compared with 2008. Several projects with new mines or capacity expansions by current producers have been delayed due to rising costs and delays in integration with new downstream production. Rock supply is projected to increase in East Asia, Africa, Latin America, West Asia and Oceania. If all projects proceed as scheduled, a large potential surplus may develop in the export market in the near term.

The global phosphoric acid capacity is forecast to increase by 10.8 million tonnes in 2008 to 55.3 million tonnes P2O5 in 2013. About 88 percent of this increase will be dedicated to domestic downstream processing. The main additions to capacity will occur in China, Saudi Arabia and Morocco. The net addition to merchant grade acid capacity is estimated at 1.3 million tonnes P2O5, of which 1.2 million tonnes will come from three units in Jordan, Morocco and Tunisia. No new tonnage of non-contracted merchant grade acid capacity is expected to be available before 2013. United States production of phosphate rock is shown in Table 3. The top ten phosphate producers in the world are shown in Table 4.

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