FRIENDS, FOES AND FORESIGHTS IN THE NUTRIENT SUPPLY CHAIN

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Abstract

In mid-2008, the prices of urea and TSP rose by 2.6 and 3.7 times respectively while in January 2009, the price of KCl rose by 3.4 times above their respective price trend lines. These changes reflect perceived and actual confidence in the supply of these essential fertilizers.

The reliability of fertilizer supply is usually considered only in terms of the lag from production to delivery and unanticipated demands from farmers. In future, the supply of fertilizers may depend more on global events than in the past. Supply of nitrogenous fertilizers is increasing governed by the supply of natural gas as a feedstock. The supply of natural gas for fertilizer production is affected by energy demands, offshore shipment to fulfil long-term contracts and price on the world market. Use of legumes has decreased due to relatively low cost of nitrogenous fertilizers and the high value of non-leguminous crops and pastures. Should nitrogenous fertilizers become less available, the technology for developing strains of Rhizobium and legume breeding should be maintained.

There are abundant global reserves of potassium with very large deposits in Europe, Canada and the US. Furthermore, potassium can be recovered from seawater. On the other hand, phosphate resources are more limited, many in more geopolitical regions.

This paper examines the risks to fertilizer supplies, resource consumption on per capita basis and economic price spikes. Preparedness is paramount.

Introduction

The population of the world now exceeds 7billion people and food security is of ever increasing concern (Lott et al 2011). The production of food relies heavily on fertilizer inputs to soils which are naturally deficient in, or have been depleted of plant-essential nutrients.

The cost of fertilizer may increase in the future due to real or perceived exhaustion of supplies, higher costs to extract the elements, reduced access to reserves due to physical barriers, political instability, or non-export policies by counties with reserves, increased transport costs, and a lack of access to credit to purchase fertilizers.

The cost of fertilizer inputs is already quite high as a proportion of the costs of production. Further increases in the cost of fertilizers could quickly lead to sub-optimal rates of application and hence lower crop yields.

In this paper we consider the fluctuations in the price of the major fertilizers (N, P and K) as a way of drawing attention to the need to utilize fertilizer inputs more efficiently. The challenge to produce more food per unit of applied fertilizer is particularly relevant to Australian and New Zealand agriculture which have limited fertilizer reserves and export a large proportion of their agricultural produce. We must adopt policies and initiate further research which leads to fertilizer–efficient technologies that help us reduce our dependence on fertilizers. If fertilizers become less available and/or more expensive, preparedness is paramount.

Materials and Methods

Data for populations and fertilizer usage were sourced from official published UN and FAO websites. The most recent data are often revised in the following year as more reliable data become available. Data lags vary between 2-3 years. Notwithstanding these possible discrepancies, the overall trends are robust. Data on international fertilizer prices were obtained from Index Mundi.   Reserves of phosphate were sourced from USGS data. This paper examines trends in fertilizer prices over a 15 year period and reserve [fertilizer] usage per capita. Where appropriate, data analysis was performed with SSPSStastics (Macintosh version 22, IBM).

Results and Discussion

Prior to mid-2004, prices of N, P and K fertilizers, either on a commodity or an elemental basis, were quite stable (Figure 1). Due to the differences in composition of TSP, elemental basis is somewhat more variable than for either urea or potassium chloride. From June 2007, fertilizer prices rose multiple times: in 14 months, the price of TSP had risen to over $1100/t, a clearly unsustainable price for agricultural activities given the prices paid for commodities. Urea prices peak about two months after that for phosphate fertilizers. Potassium fertilizer prices did not peak until February of the following year.

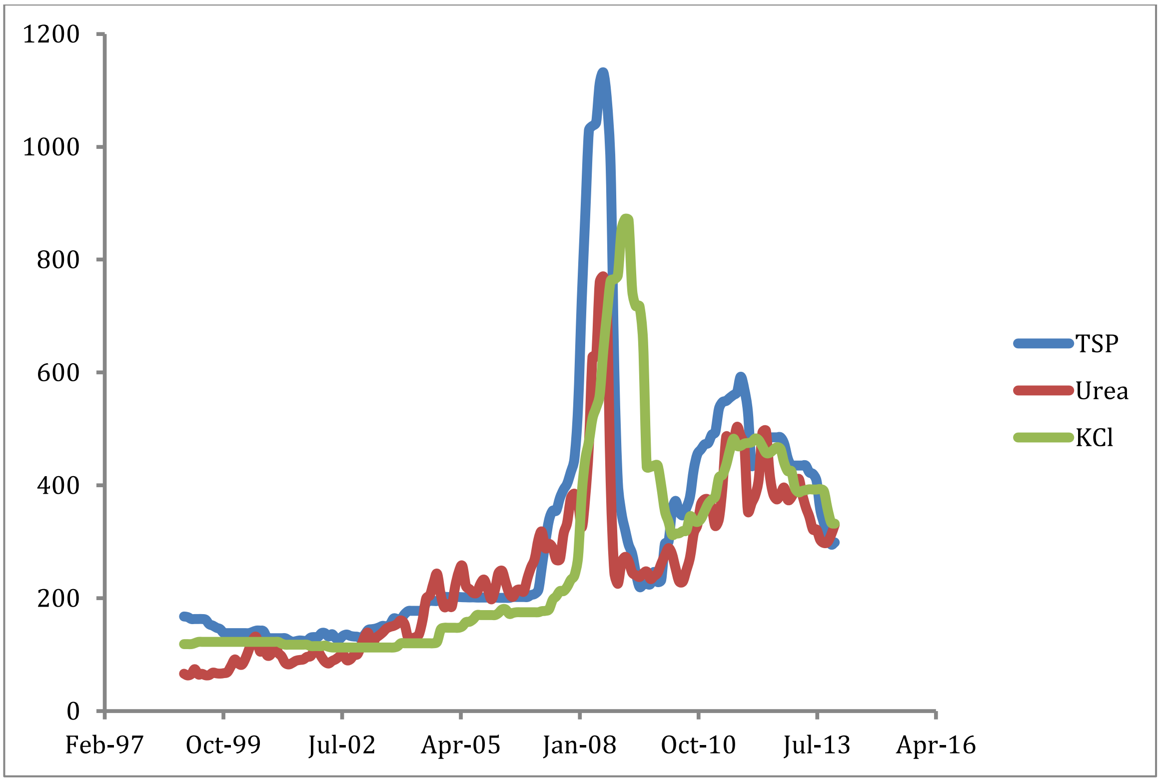

Figure 1.   Fertilizer prices ($/t) over the past 15 years.

There was a moderately good correlation (r^2=0.8) between P (TSP) and N (urea) prices during the past 15 years. It is hypothesised that farmers first decide to purchase phosphate fertilizers before purchasing nitrogenous fertilizers. Of course, purchases of compound N and P fertilizers confound this hypothesis.

This paper only considers reserves of an element and not the resource. Reserves are effectively the amounts that can be economically mined or recovered with current technology. Phosphate reserves are heavily concentrated to a very few regions (Figure 2). North Africa has the greatest reserves. Surprisingly, the top four regions or countries have about 93% of the current reserves. Thus, distances and locations for shipment to Oceania can have a major impact particularly if some major disruption or crisis occurs. Furthermore, the quality of the reserve varies between regions; the Oceania reserves are not as high quality as those from major sources. As a consequence, phosphate fertilizer prices would rise substantially should restrictions occur. In recent years, proven reserves have increased.

All too often, debate is clouded by the reserve or resource issue. By and large, the resource is the fixed quantity. As the price of the commodity rises, more of the resource is transferred to the reserve. Furthermore, breakthroughs in technology (e.g. in recycling) can increase the reserve.

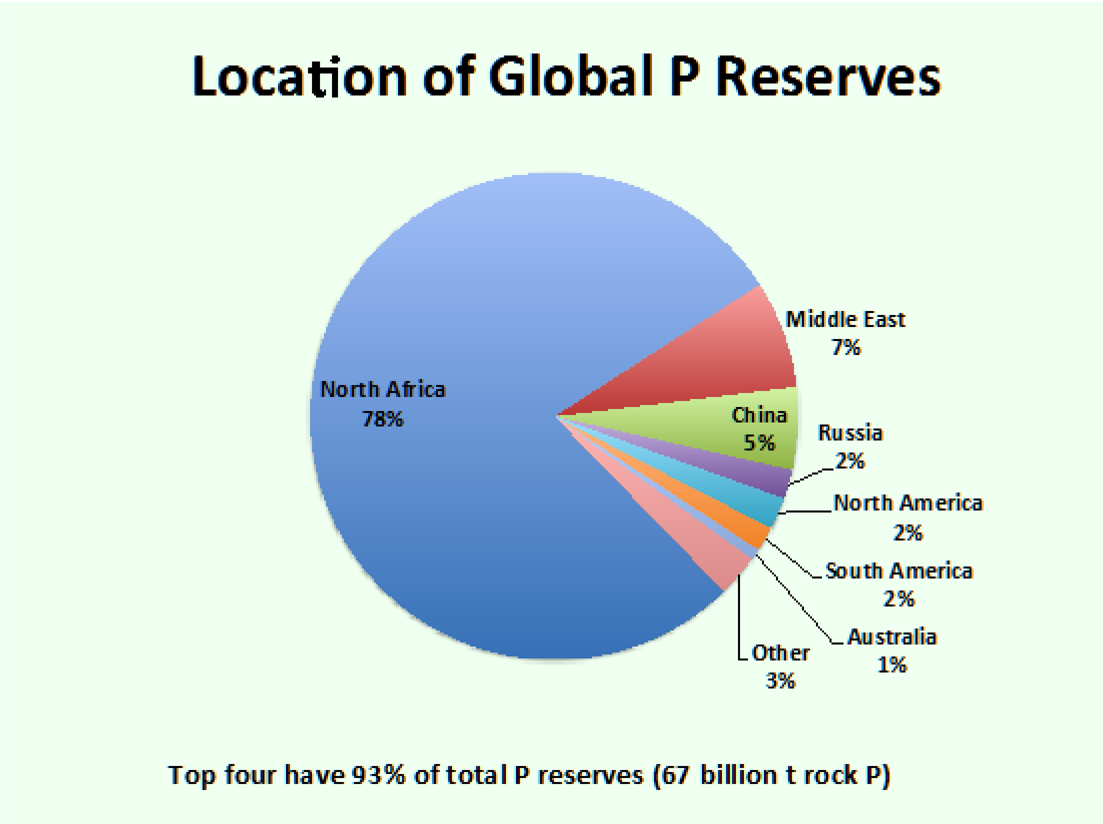

Figure 2. Global rock phosphate reserves and their location.

Potassium reserves are held in Canada and the northern parts of the US totalling about 41%; in fact, the US also holds extensive resources very deep underground in the same areas as its reserves. Between Russia and Belarus, a similar reserve to the North American reserve occurs (Figure 3).

As seawater contains considerable potassium, it is feasible with perhaps a moderate increase in price, to extract potassium (chloride) in evaporative ponds. One such venture was started in Australia but it is not known what is the current state.

A debate should occur about the desirability of using potassium chloride as a fertilizer rather than potassium sulphate (or some other potassium salt). The latter (sulphate) is more expensive than chloride. However, the long-term desirability of using chlorides should be evaluated, or in some instances investigated, for their effect on the environment including soils, on plant growth and their ability to be transported into waterways.

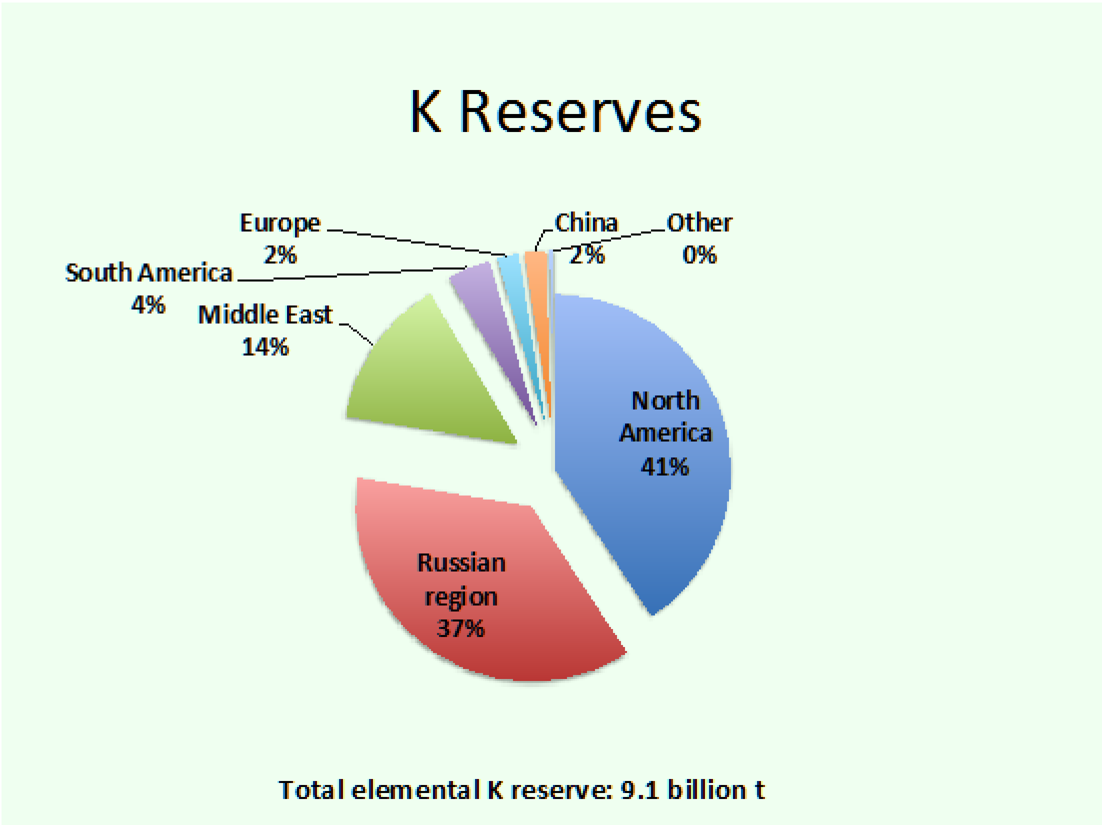

Figure 3. Global potassium reserves and their locations.

Nitrogen fertilizers are made either synthetically or by biological nitrogen fixation, which in terms of Oceania, is largely via legumes and a few other nitrogen fixing species e.g. *Casuarina sp*. The major feedstock for synthetic nitrogen fertilizers is natural gas which is widely distributed globally. Furthermore, production of nitrogen fertilizer is scattered around the globe in line with the distribution of the feedstock. Thus it is relatively meaningless to discuss nitrogen reserves per se. However, it more important to note that fertilizer nitrogen is energetically expensive to produce and thus its price should be influenced by the cost of natural gas notwithstanding sudden spikes in demand which can alter the price in the short run. Disruption to transport can also influence the price of nitrogen fertilizer.

The role of biological nitrogen fixation has tended to be overlooked in recent decades. It is our considered view that this resource should be investigated further. For example, research on more efficient [*Rhizobium]* bacterial strains, nitrogen fixation by non legumes, gene transfer, farming systems with nitrogen fixing species incorporated etc. could be very profitable.

New Zealand and Australia are the major users of fertilizers in Oceania accounting for 32% and 67% respectively of the usage of phosphate fertilizers in the region. However, when (all) fertilizer usage is place on an arable land area or cultivated land area, New Zealand's usage is about 17 times that of Australia. Another measure is to place resource use on a per capita base; Figure 4 presents the data for P use per capita.

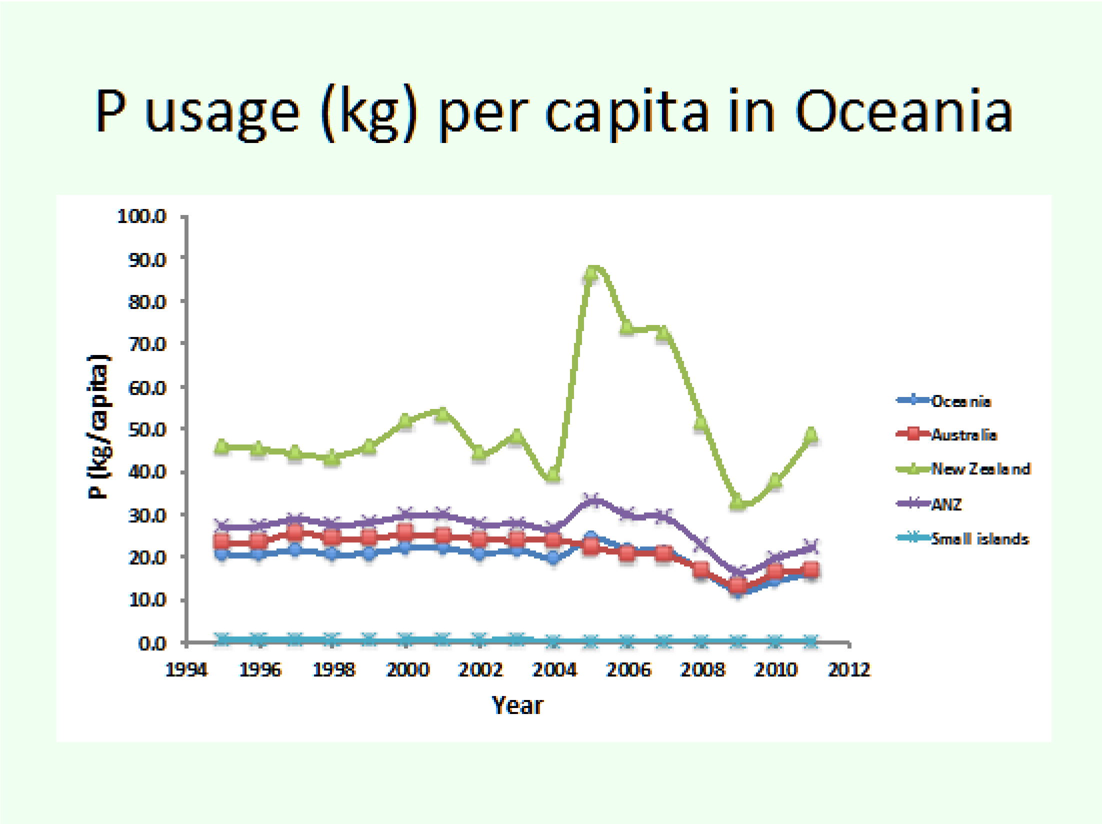

Figure 4. Phosphorus usage per capital in Oceania over the past 15 years.

New Zealand has about twice the phosphate fertilizer use of Australia whereas usage by the small islands of Oceania is less than 0.5 kg/ha and decreasing in part due to the rapid population growth in the small islands. The sudden rise in phosphate fertilizer usage in the period 2005-2007 is not easily explained even taking into account possible expansion of the dairying industry.

As both New Zealand and Australia are both large exporters of agricultural commodities, it may be wiser to express usage on a P use per capita fed rather than the bland statistic of country population. On this basis, P use per capita fed is broadly in line with usage/capita for the world. In other words, Australia and New Zealand need to defend their use of fertilizers on the basis that they export agricultural products to feed many millions in other countries.

As reserves of phosphorus and to some extent potassium are finite without massive changes in technology or costs, both these resources need to be managed carefully. Furthermore, some resources are in geopolitical regions that could become unstable and hence access to the resource could be limited by various factors including war, terrorism, blockades, oil shocks, shipping crises, population explosions as occurring in Africa and the small islands of Oceania, mass migration etc. Thus countries in Oceania, particularly Australia and New Zealand, should develop strategies to mitigate against such events and to have a high degree of resilience.

Strategies that should be developed include genotypes (of crops and pastures) that are efficient in either or both of phosphate acquisition and physiological and metabolic usage. At a research level, the question should be asked 'why do the internal phosphate concentrations vary between species?'.

Phosphate loss is commodities can be considerable. For example, phytate in grains is not metabolised by monogastric animals including humans and thus is excreted. Thus the development of low phytate grains may be a strategy to conserve phosphate but it may have unintended consequences. Another example is the amount of phosphate exported in milk and grains – this can amount to $50/t of milk powder or up to 6% of the value of grain. For research, a reduction of the amount of P in milk would seem highly desirable.

Another way to deal with limited resources is to develop food cycles for P, N and K. Recycling these nutrients captured at various points in the food chain is not trivial and low cost methodologies need to be 'invented'.

Resources per capita raise interesting scientific and sociological questions. The solutions of limiting population positive growth are not facile; concomitant with part of population growth has been the expectation of higher consumption of food both energy (calories) and protein. Thus resources are increasingly strained. We advocate that multiple strategies be developed to deal with any actual or perceived limitation of the supply of fertilizers.

Reference

J.N.A. Lott, J. Kolasa, G.D. Batten and L.C. Campbell. The critical role of phosphorus in world production of cereal grains and legume seeds. Food Security, 3(4), 451-462 (2011).