THE AUSTRALIAN NUFFIELD FARMING SCHOLARSHIP TRUST

LIQUID FERTILIZERS

A STUDY ON LIQUID TECHNOLOGY AND ITS FUTURE ROLE IN INFLUENCING NUTRITIONAL OUTCOMES ON THE CALCAREOUS SOILS IN SOUTHERN AUSTRALIA

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SPONSORED BY:

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EXECUTIVE SUMMARY

My Nuffield Scholarship was split into two halves. The first six weeks in February/March were spent between Asia, Europe and the United Kingdom with my fellow scholars. Two weeks in Malaysia and Thailand gave us an incredible insight into Asian culture and agriculture, then four weeks in Europe touring the United Kingdom, France and Belgium. The big issues there being the massive impact Foot and Mouth had on the United Kingdom and the changing face of the European Economic Community's involvement from production based subsidies to a program dominated largely around environmental issues for the European farmers.

I then left the organised tour and fellow scholars to plant my crops. I then travelled to the United States and Canada for three months to study liquid fertilisers. I set out to confirm that the principles of the agronomic and nutritional advantages achievable under a liquid regime as researched by the South Australian scientists were endorsed by agriculture in the United States and Canada.

I then looked at how liquid fertilizers were manufactured and the liquid fertilizer business in general. It is a highly developed mature industry in North America, supplying 22% of the nutritional market in the United States and 30% in Western Canada.

There are many advantages to agriculture through the use of liquids.
These are –

- The ability to band nutrients
- Improve Phosphorus nutrition
- The ability to mix and match nutrients and ratios to suite different nutritional needs
- Weed and feed
- Product uniformity
- Logistics (handling)
- More environmentally responsible
- Yield improvements
- Easily adapted to current day machinery
- The ability to incorporate micronutrients into the root zone

In Australia we currently face an increasingly growing demand for and interest in liquid fertilisers and are serviced by a very enthusiastic but immature industry where supply and costs are the two biggest factors limiting its growth potential. There is however absolutely no doubt that as farmers become more aware of the advantages of liquids and supply and price issues improve, there will be prospects for exponential growth.

AIMS AND OBJECTIVES

The aim of my study tour was to research the complete cross section of agriculture and industry involved in the use and production of liquid fertilizer.
My initial focus was to confirm that the principles of the agronomic and nutritional advantages achievable under a liquid regime as researched by the South Australian scientists were endorsed by agriculture in the United States and Canada.

I quickly ascertained that Australia's current research into liquids was held in high regard in the United States and Canada, and set out to learn all the advantageous principles that liquid fertilisers can give. And so with some answers quickly confirmed I tended to concentrate my pursuit of answers on the actual industry of liquid fertilizers, investigating in more depth the actual manufacturing and distribution process.

The United States conducted extensive research into liquid fertilizers 40 years ago, but have never reported the responses compared with granular fertilizer that is evident on the high pH soils of Southern Australia.

ACKNOWLEDGMENTS

Firstly, I would like to thank the Australian Nuffield Farming Scholarship Foundation for giving me the opportunity to pursue my interests and travel around the world doing it in a way that I would never have had an opportunity to do otherwise. No matter how successful communication technology maybe these days it could never replace the first hand experiences and the wonderful people and contacts I made through this scholarship. Meeting the people and observing the industry at first hand is invaluable.

I would like to sincerely thank the sponsors, Qantas for the airfares and the Grains Research and Development Corporation as my major sponsor for their generous support.

In my absence the farm kept going and I sincerely thank my wife Tracey and parents Herman and Ria for the extra sacrifices made.

Through my whole North American program I relied totally on Dr Larry Murphy, President of the Fluid Fertiliser Foundation, USA. An unreserved thankyou goes out to Larry. It was because of his organisation and help that the quality and kindness of all my contacts was of the highest order.

To all the people who hosted me in Europe and the United Kingdom and then both my family and I in North America, I am sincerely grateful for your unforgettable hospitality.

INTRODUCTION

Static yields and low early plant vigour are the two critical challenges in growing crops on the calcareous high pH soils of South Australia. There are over one million hectares of this soil type in South Australia. Poor early phosphorus nutrition is the culprit for this slow early growing behaviour. Therefore in our pursuit of improving phosphorus nutrition in these soils we were led to liquid fertilizers.

Since the Minnipa Agricultural Centre did the first trials in 1997 much has been learnt. Early growth and grain yield improvement trends were very exciting and now based on this data some farmer's are changing their whole farming system to liquids. Of course major decisions need to be based on trends from long-term high quality results and technological information, with sound agronomic and nutritional explanations for the results. As we learn more the picture appears to be broadening and more diverse soil types may well come under the umbrella of benefits from liquid fertilizers.

In this report I will discuss the background of P nutrition as it relates to calcareous soils, and how, when and why liquid fertilizer technology will become an increasingly valuable tool in improving soil nutrition on some Australian soils, and why we need liquid products that will fulfil our agricultural needs.

The liquid fertilizer technology available today has most of its roots in North America. I will provide a background for this and then discuss the types of liquids available today and manufacturing of liquids for broad scale agricultural production here in Australia.

THE CALCAREOUS SOILS DILEMMA

Alkaline soils are abundant throughout the world and constitute a major resource for agricultural use. In Australia sodic and calcareous soils are widely represented throughout the agricultural regions, particularly those with semi-arid climates. Calcareous soils occur commonly in the western and southern parts of South Australia and are mainly cropped with wheat and barley.

The agricultural region of the Eyre Peninsula is a prime example. It is largely devoted to wheat production and has traditionally produced about 40% of the state's crop. There is a region on upper Eyre Peninsula of one million hectares characterised by grey highly calcareous sands and sandy loams adjacent to the coast, which produces approximately 10% of the state's crop. These soils have concentrations of calcium carbonate varying from 10 to 90% and are based on wind blown sea floor material deposited during a previous ice age when the sea level dropped. Important in extent too are the brown and red calcareous sandy loam soils found further inland that are largely aeolian and contain calcium carbonate levels generally between 5 and 10%.

While improvements in cereal agronomy based on rotations and more intensive fertilizer use has seen steady improvements in yield and water use efficiency in crops in other areas of South Australia, mean wheat yields on Upper Eyre Peninsula have, whilst not remaining totally static, struggled to improve at a rate equivalent to other areas of South Australia. Investigations into the problem have identified P as the major limiting factor. Phosphorus is one of the major nutrients limiting agricultural production in many areas of the world and certainly this is the case in Southern Australia.

Despite 70 years of P fertilization with granular fertilizers on the grey calcareous soils of Upper Eyre Peninsula research has shown that wheat grown under increasing ratios of P in the form of granular fertilizer only demonstrates a flat response curve. An important characteristic of wheat in low rainfall calcareous soils is slow early development, poor tillering and late uneven ripening.

Nutrient availability is largely effected by soil chemical characteristics immediately surrounding the point of nutrient application. P availability and uptake of P from commercial P fertilizers is dramatically effected by soil reactions with various cations Ca, Mg, Al, Fe and in our soils more particularly Ca.

Phosphorus applied in the granular form quickly becomes immobilized on these high pH calcareous soils. Conditions are quite often dry and so the soil solution is concentrated, therefore the concentration of P around a granule can be very high and so it easily becomes immobilised by reacting with the Ca ion. All nutrients being picked up by the roots of plants must go through this soil solution.

The addition of concentrated phosphorus compounds to calcareous soil forms insoluble tricalcium phosphate compounds, tying up the phosphorus molecule. This tie up is known as fixation. Soluble P is the only form of P which plants can absorb and the ideal pH for P solubility is around pH 6.5.

Plant leaf tests on these alkaline soils typically indicate low P levels even when soil tests indicate these levels are adequate. These soils have also been shown to have extremely high P absorption capacity despite high levels of total P. With this in mind, and the fact that research has shown that neither current application rates of conventional fertilizers or increasing rates of application would solve the problem of these soils, the ability to economically provide wheat plants with sufficient phosphorus on calcareous soils awaits a major change in fertilizer technology.

PHOSPHORUS AND NITROGEN NUTRITION

The two macronutrients that are of most importance to grain growers in southern Australia are phosphorus (P) and nitrogen (N). A large number of studies in many plant species have shown that early season P supply is critical for optimum crop yield. Withholding P during early plant growth will limit crop production and cause a restriction in crop growth from which the plant may not recover. Phosphorus limitation later in the season has a much smaller impact on crop production than do limitations early in growth.

Phosphorus is critical in the plants metabolism, playing a role in cellular energy transfer, respiration and photosynthesis. Moderate P stress may not produce obvious deficiency symptoms. These symptoms can be mistaken for symptoms of other stresses. However with a more severe deficiency plants become dark green to purplish in colour and ultimately cell growth is delayed and potentially stopped. These effects are demonstrated by a decreased plant height, delayed leaf emergence and reductions in tillering, secondary root development, dry matter and yield. The effect on tillering is perhaps the most important, since 95% of wheat yield is generated from the main stem and the first two tillers. Many wheat crops grown on highly calcareous soils have a main stem only.

Most phosphate moves to the plant by diffusion rather than mass flow and so the rate of diffusion is generally considered to be the rate-limiting factor in P absorption by plants. It is estimated that phosphate can only diffuse 0.5mm from its source so that only phosphate within 0.5mm of a plant root is positionally available for absorption.

Maximum tiller production, head size and formation, are the two most critical yield determinants for wheat and these are governed by P nutrition in the 2 – 6 week period of early growth. The availability of P in this early growth period has a massive impact on crop yield and so it is critical that P fertilizer applications are managed in a way that ensures early season access to the fertilizer by the growing crop.

Nitrogen is also essential for plant growth. It is a part of every living cell. Plants require large amounts of N for normal growth. Nitrogen is necessary for chlorophyll synthesis and as a part of the chlorophyll molecule is involved in photosynthesis. Lack of N and chlorophyll means the crop will not utilise sunlight as an energy source to carry on essential functions such as nutrient uptake. Nitrogen is also a component of vitamins and energy systems in the plant. It is an essential component of amino acids, which form plant proteins. This N is directly responsible for increasing protein content.

Adequate N produces dark green colour in the leaves, caused by a high concentration of chlorophyll. Nitrogen deficiency results in yellowing of the leaves because of declining amounts of chlorophyll.

This yellowing starts first on oldest leaves, then develops on younger ones as the deficiency becomes more severe. Slow growth, stunted plants and a reduction in tillers are all consequences of Nitrogen deficiency.

The soil contains a relatively large proportion of unavailable (organic) N and a small proportion of available (inorganic) N. The process by which unavailable organic forms are converted to available forms is important to plant growth. This process is called mineralisation, it occurs as microorganisms decompose organic materials for their energy supply. As the organic matter is decomposed, the organisms use some of the energy released plus part of the essential nutrients in the organic matter. When the organisms have used all the nutrients they need the excess is released for plant growth.

The reverse of mineralisation is immobilisation and is the process of converting nitrogen from the inorganic to organic form. It occurs when crop residues high in carbon and low in N content are incorporated into the soil.

Soil pH, moisture, temperature, aeration's and plant residues are all factors influencing the N balances. With this understanding the important part of fertilizer N management is to apply proper rates and sources, place the N for best use efficiency and to time applications to the periods of greatest crop need.

Distinguishing between the nutrient for liquid use

Having given a background to the importance of these two critical macronutrients, it is critical to distinguish the "need differences" between the two nutrients. Because of the differences in their ability to diffuse through the soil and differences in the diversity of their immobilisation, it must be remembered that these factors have a critical influence on the form of nutrient used and where it is placed. The benefits of placing liquid phosphorus in a continuous band below the seed have been proved time and time again and are considered to be the best way to administer phosphorus. Because of the ability of N to move rapidly through the soil water, its best placement and form are not easily defined. However the added benefit of having a mix of nutrients in the liquid band including N and trace elements is also being better understood.

LIQUID USE AROUND THE WORLD

USA

Fluid fertilizers including anhydrous ammonia accounts for 52% of the single nutrient and 22% of the multiple nutrient tonnage of fertilizers used in the USA. More than 18.1 million tons of fluids are sold annually in the United States, accounting for about 40% of the 45.2 million tons of primary nutrient fertilizers sold.

The development of the modern fluid fertilizer industry really did not take off until the end of the 2nd World War. The nitrogen solutions available at the end of the war and the ample supply of phosphoric acid in the 1940's led to the use of large quantities of fluid fertilizers.

The industry was greatly advanced by the development of superphosphoric acid, the pipe reactor and suspension fertilizers. These advances resulted in an increase in the nutrient content (analysis) of fluid fertilizers. The average N – P_2O_5 – K_20 analysis of a ton of fluid fertilizer in 1960 was about 28%. It then increased to 35% by 1981 and to 44% by the 1990's.

Much of the early use was attributed to the increased use of suspensions. Introduced into the late 1960's suspensions in 1974 accounted for the 25% of total mixed fluid fertilizers and then to 40% by 1984. However they have declined markedly through to this day where, with farming practices changing dramatically the use of the clear liquid mixed nutrient forms such as ammonium poly phosphates have almost completely taken over.

Along with the trend to increased nutrient analysis, there was a simultaneous development of equipment capable of handling and applying fluids safely, quickly and economically. The rapid growth in the liquid market can also be attributed to the knowledge of the manufacture and use of fluids made available by the Tennessee Valley Authority, various universities, the National Fertilizer Solutions Association and the Fluid Fertilizer Foundation.

Today there is a price premium of liquid nutrients over dry blend fertilizer in the USA. Due to the USA's generally intensive high production agriculture, they can and will consume all the liquid production that is possible in North America and accept this premium for the product they believe will offer them the most advantages.

CANADA

Canada has followed the path of fluid development with the USA, but without having quite the same rate of growth. Western Canada consumes 30% of its total nutrient use in liquid form, including the use of anhydrous ammonia. 85% of the fertilizer used in Canada is sold in Western Canada. Western Canadian agricultural production is quite similar to Australia. However a price premium for liquid nutrients of approximately 15-20% above the price of granular is the biggest stumbling block to use and continued growth of liquid fertilizers in this part of Canada.

EUROPE

Fluid fertilizers are not as important in Europe as they are in North America. This is probably related to farm size and the availability of distribution, storage and application facilities. Total fluid use in Europe is estimated to be around the 2%. Nitrogen solutions account for most of the liquid use holding about 7% of consumption in Western Europe, 8% for the countries of Central Europe and approximately 5% in the case of the Russian Federation.

WHAT ARE LIQUIDS?

Nitrogen Solutions

The most popular nitrogen solution is the non-pressure solution urea ammonium nitrate (UAN), which usually has a 32-0-0 or 28-0-0 grade (32% or 28% N, w/v). In Australia because we don’t have the salt out problems from the cold temperatures of the Northern Hemisphere the 32-0-0 grade predominates. About 50% of the nitrogen is derived from each of ammonium nitrate and urea.

In North America the use of anhydrous ammonia (under pressure) is also very popular mainly because of its price. Consumption is declining however as the awareness of its hazardous nature and safety standards increase.

Manufacture of Urea ammonium Nitrate (UAN)

UAN solutions are usually made from hot ammonium nitrate and urea solutions. Two types of production processes used are batch and continuous. Both are simple. In each process the concentrated urea and ammonium nitrate solutions are measured, a corrosion inhibitor added, the solutions are mixed, cooled and then pumped to storage. There are several inhibitors that may be used, ranging from borax to ammonia to one of the most common being ammonium polyphosphate (APP).

Other nitrogen solutions

Ammonium thiosulphate (ATS) 12-0-0-26. This nitrogen-sulphur solution is experiencing continual growth in North America because of its compatibility with other liquids and its ability to supply sulphur. It is only new in Australia and currently being exported from the USA. With the ever-increasing need for sulphur into our farming systems, because of the popularity of canola and the now almost total use of high analysis fertilizers without sulphur impurities, ammonium thiosulphate demand will only continue to grow. ATS contains 12% N and 26% S. The steps in its production process are as follows –

Burn elemental sulphur
I
Sulphur Dioxide
+
Water
I
Sulfurous Acid
+
Ammonia
I
Ammonium Sulphate
+
Ammonium + Sulfur
I
ATS

The capital investment per unit of production is high compared to other nitrogen solutions. It is an excellent source of nitrogen and sulphur for direct application and for clear liquid and suspension mixtures. It is a non-pressure solution that can be stored in mild steel tanks. ATS is phytotoxic to the seed and so care must be taken when put close to the seed. The addition of sulphur to a mixed set of liquid nutrients is extremely beneficial.

Sulphur is an acidifying agent that helps in phosphorus availability by keeping the calcium molecule away from tying the phosphorus up. There is also a collaborative nutritional symbiosis between nitrogen and sulphur. As nitrogen requirements increase so too do sulphur requirements increase. The practice of no tilling will also necessitate higher sulphur requirements. ATS is also a reducing agent and helps to liberate manganese by providing the insoluble Mn++++ molecule with electrons to reduce it to Mn ++, which is soluble. If ATS is used in conjunction with UAN in the post emergent surface banding of Nitrogen then it will help slow the conversion of urea to ammonia.

Other solutions such as aqua ammonia, ammonia-urea solutions and ammonia-ammonium nitrate solutions have some potential but are currently not used in any significant amounts around the world.

Phosphorus solutions

The two most common forms of phosphorus solutions are ammonium orthophosphate solution or ammonium polyphosphate solution. The distinguishing factor between these two solutions is the grade of phosphoric acid used in its manufacture. Most of the phosphoric acid for fluid fertilizers is produced by the wet process method. Ground phosphate rock is treated with dilute sulphuric acid or a weak solution of phosphoric acid. It is filtered from the gypsum and other solid impurities. The filtered acid is concentrated and again filtered. This concentrated acid is called “merchant grade” acid and usually contains 54% P_2O_5. (23% P w/w). This acid is orthophosphoric acid, H_3PO_4.

A stable solution of 8-12-0 (N:P) grade can be made by ammoniating merchant grade orthophosphoric acid. This is called hot mixing and uses ammonium polyphosphate 10-16-0 as a source of part of the final products phosphorus. This product normally contains 45% polyphosphates.

To make ammonium polyphosphate (the “Rolls Royce” of liquid fertilizer) superphosphoric acid is an essential basic requirement. When orthophosphoric acid is concentrated above 68%, water molecules are driven out by the heat and phosphorus molecules are formed that contain more than one phosphorus atom. These are polyphosphoric acids and a mixture of orthophosphoric acid and polyphosphoric acid is called superphosphoric acid. Superphosphoric acid is produced by continuing to concentrate the merchant grade acid and then centrifuging the water off. The acid is usually dark green and high in viscosity. It contains 68-70% P_2O_5 (27-30% P w/w).

The most convenient way to convert superphosphoric acid to a high polyphosphate “melt” is to react the acid with anhydrous ammonia in a plant called a “Tee” reactor. “Melt” from this pipe reaction is mixed with water and additional quantities of ammonia to produce an ammonium polyphosphate (APP) solution, which has 70-75% of its P_2O_5 (P) as polyphosphate. Usually a grade of 10-34-0 (w/w) (14:21:0 w/v) is produced.

APP is now the most desirable liquid form of phosphorus in the world. APP materials make possible the production of higher grades. Its polyphosphate characteristic allows it to form stable complexes with calcium, magnesium and metal micronutrients. It has the ability to “sequest” or chelate nutrients. Because of the sequestering properties of polyphosphate, metals are significantly more soluble in 14:21:0 than in the orthophosphate solution.

Ammonium polyphosphate supplies NH_4+ (ammonia) which the plant uses and in turn releases H+ through the roots. This helps it to acidify the rhizosphere, which then helps release P in high calcium carbonate soils. It is thought that APP in high $CaCO_3$ soils might be responsible for liberating phosphorus from the fixed pool in the soil.

Micronutrients

Most micronutrients have low solubilities in liquid mixtures unless a sequestering compound is present. It is commonly accepted that the micronutrients are more effective when chelated with organic compounds such as EDTA. Unfortunately zinc, manganese and copper sulphate are relatively insoluble in ammonium polyphosphate solutions. Up to 2% of the solution can be added as zinc sulphate but there is a fine line between maintaining a clear solution and forming a precipitate. Manganese is 10 times less soluble in ammonium polyphosphate. Generally, chelated micronutrients such as zinc EDTA and manganese EDTA can be dissolved in ammonium polyphosphate at useful rates. Recent research has shown that zinc sulphate can be successfully dissolved in ammonium polyphosphate if about 30% of the P is supplied as phosphoric acid. There is also some evidence now that ammonium polyphosphates are able to sequester micronutrients in the soil and release them from insoluble compounds.

Generally manufacturers of orthophosphate fertilizers use organic complexes or chelates while those producing polyphosphate solutions may use inorganic sources, taking advantage of the sequestration by polyphosphates. This is a very important factor to consider where micronutrients are needed as part of the total nutrient package.

Liquid mixtures

The fluid mixed fertilizer industry is divided into two parts. Liquid mixtures and suspension mixtures.

Liquid mixtures are defined as fluids in which all the salts are in solution. They are often referred to as clear liquids. The main materials used to produce liquid mixtures are ammonium polyphosphate solution 10-16-0 (14:21:0) urea ammonium nitrate 32-0-0, phosphoric acid, ammonia solution, ammonium thiosulfate, micronutrients and other soluble additives.

Suspensions

Suspensions are defined as fluid fertilizers that have solid nutrients dispersed throughout the fluid.
They are saturated solutions that have solid nutrients held in suspension by a suspending agent such as altapulgite or bentonite clay. These clays cause a fluid gel to form, helping suspend the solids in the saturated solution.

These fluids usually have from 10-40% of their total weight as suspended solid particles. Almost any solid or liquid material can be used in suspensions as long as the solid particles can be broken down to less than 1.0mm and do not have a tendency to grow in storage. As the number of particles increase per unit of suspension, the viscosity increases.

The stability of the suspension fertilizer depends on –

- Type of clay
- Amount of shear
- Gel characteristics
- Solid content of the fluid
- Raw material impurities
- Efficiency of the ammoniation reaction
- Mixing of the solid materials and solutions

Most suspensions are produced in a batch hot mix plant, which has a mix tank and cooler. The suspension mixtures are mostly produced from the ammonium phosphates such as MAP and DAP.

In the production of base suspensions from MAP, the solid materials are mixed with water, while ammonia is added to the mixture to adjust the N:P ratios to 1:1.35. At this degree of ammoniation all of the crystals in suspension are as DAP. DAP crystals are desirable over MAP crystals because they have a lower specific gravity therefore are less likely to settle. They are also cubed shape and not cylindrical like MAP which gives them less tendency to plug the nozzles and tubes of an applicator.

Another form of phosphate suspension is using DAP, merchant grade phosphoric acid and ammonia. The DAP based suspension make a grade of 11:16:0 while the MAP suspension grades in at 10:15:0.

Suspensions whilst having lost favour in North America over the last decade have a number of important advantages, the most important of these is that suspensions allow you to use a large variety of low cost less refined solid and liquid raw materials containing insoluble impurities and therefore bringing its cost down to a level competitive with suppliers of dry fertilizers.

Potash based suspensions also gave the opportunity for manufacturers and farmers to have high levels of potassium in the mix, levels which are not attainable in the clear liquid form.

The use of suspensions not only allows the use of less expensive sources of the major plant nutrients but also permits the use of less expensive forms of minor elements. Whilst clear liquid mixtures dominate the world market there is also a place for suspensions given their price advantages. In North America the practice of using suspensions occurs –

- Where high levels of potassium are needed.
- When surface applications of nutrients through terrogators are used.
- Where farmers have set their machines up with the green pot distribution systems and are drilling in a mix of nutrients prior to seeding.
- Where cost is the major factor.

The alternative is one pass precise placement technology where the complete but more expensive clear liquid nutrient mixtures can be used through an orifice system without any problems at seeding time.

LIQUIDS – ADVANTAGES

- The ability to provide a continuous band of nutrients in the root zone
- Improve P nutrition
- Mix and match
- Incorporating trace elements
- Weed and Feed
- Improve yields
- Easy to use (handling)
- Product uniformity
- Easily adapted
- Environmentally responsible

Banding

Root zone banding

The use of liquids is the only opportunity available to a farmer to create a continuous non-broken band of nutrients in the root zone below the seed. This is the best possible position for good plant growth because –

- The soil is more likely to be moist down deep and so the nutrients particularly phosphorus becomes more accessible. The enhanced soil moisture conditions improve the uptake and reduces the fixation of phosphorus.
- Elements like phosphorus and zinc are relatively immobile in the soil and so their positioning is critical.
- It reduces the stratification of nutrients occurring in the soil surface under reduced tillage systems.
- It encourages deep vigorous root growth.
- By banding nitrogen in the root zone there is less tie up of nitrogen with the surface residue.
- The band of nitrogen together with phosphorus enhances phosphorus uptake
- Root zone banding is the only way that you can build subsurface nutrients without extensive deep tillage.
- Bands of liquid fertilizer resist fixation and have useful residues.
- It will improve water use efficiency.

Surface banding

Surface banding is used in North America as a compromise to broadcast application of dry blended fertilizer or surface spraying of liquids but is probably not practical in Australia. As more farmers are switching to reduced tillage but cannot or do not wish to root zone band a compromise is to surface band.

Surface banding allows the placement of nutrients onto the soil surface but in a band with quick and convenient large-scale applicators. Spray booms are modified to apply liquid fertilizer in streams rather than a spray pattern. The benefits of surface banding of liquids over broadcast application is that it creates a higher concentration of nutrients that are in less contact with antagonistic soil compounds. This enables –

- Improved root uptake
- Reduction in fixation of phosphorus and potassium
- Reduction in nitrogen loss
- More nitrogen enhances phosphorus uptake by root
- Improved P nutrition

As stated earlier, phosphorus nutrition is absolutely critical to the plants growth especially in the early stages. Most yield forming characteristics are governed by early P nutrition.

In numerous trials over a number of years liquid P has been 2-5 times more efficient in supplying phosphorus to the plant than alternative granular forms. Whilst the different P liquids, orthophosphate, polyphosphate or phosphoric acid may have different characteristics in their form, grade, pH and ability to sequester trace elements, their conversion to the ortho form in the soil and therefore their ability to supply early available phosphorus is similar. It is the higher rate of solubility and the ability to liberate P already present in the soil that sets ammonium polyphosphate apart from other fertilizers.

Mix and Match

One of the major benefits in using liquid fertilizer is the ability to mix and match nutrients and ratios to the varying nutritional requirements needed. Differing nutritional requirements may originate from any number of factors –

- Different soil characteristics, acidity, alkalinity, trace elements deficiencies, cation exchange capacity, sodicity, amount of calcium carbonate, soil structure, base saturation, subsoil toxicities, water retention, organic matter content and geological history.
- Plant requirements for different nutrients do vary eg. canola’s high requirement for nitrogen and sulphur.
- Farming practices. The differences that must be managed for high stubble residues, no-tillage farming, continuous cropping and pasture growth requires flexibility in nutrient applications.

With these differences in mind, the opportunity liquids give to solve particular problems with particular combinations of nutrients is highly beneficial. The compatibility of the three main clear liquid solutions such as UAN, APP and ammonium thiosulphate gives the farmer an opportunity to vary the amount of all three essential nutrients N, P and S to any level desired.

Where potassium is required, high rates are easily mixed into suspensions and the clear liquid potassium thiosulphate is compatible with the other clear solutions. Liquid micronutrients are also easily added (generally as chelates) to constitute a final mix of every needed nutrient at exactly the required ratio and rate.

The relationship between certain nutrients is also very important in this mix and match process, with some well-defined nutrient ratios occurring to give synergistic relationships between elements. For example a 2:1 ratio of nitrogen to phosphorus is popular as having a synergistic effect, and also a 5:1 ratio of nitrogen to sulphur. Also beneficial is sulphur's acidifying effect, which helps phosphorus uptake. There is a strong relationship between nitrogen and sulphur in the break down and build up of organic matter. Zinc and phosphorus also have a close availability relationship – too much of one can upset the availability of the other and so on. Taking into account all these factors, prescription mixing at the end use level, provides an element of vast flexibility to the grower.

Incorporating trace elements

The need for micronutrients is constantly increasing in Australia. The reasons for this are –

- Crops are now managed more intensively
- The shift to high analysis fertilizer has reduced the amount of micronutrients formerly applied as impurities in low analysis fertilizers
- Better methods for identification of deficiencies are now available
- New crop varieties

There are many and varied micronutrient sources and solutions that give rise to many micronutrient programs.

Compatibility problems of micronutrients in clear liquid mixed solutions are lessened by the correct choices of fertilizers as the source of these various nutrients. As a rule nitrates and chlorides have much greater solubility than sulphates, (eg. all nitrates of macro and micronutrients are soluble) which are appreciably higher than the oxides and the carbonates.

Chelated fertilizers are advantageous because they are less likely to form insoluble compounds in the fertilizer mix or in the soil thereby retaining high availability. Their relative effectiveness in comparison with inorganic sources (eg.sulphates) must be taken into consideration because of the higher cost of chelates. No matter what combination is chosen the availability of micronutrients combined with other essential nutrients right in the root zone is the real benefit.

Weed and Feed

The practice of “weed and feed” has long been an important agronomic management tool for farmer’s using liquid fertilizers in North America. The adoption of applying pesticides with fluid fertilizers can save time, money and other resources. The ability to combine materials is good management and has often showed to have had a synergistic effect rather than if the chemical and fertilizer had been applied separately, ie.combinations such as trifluralin and a nutrient mix, a fungicide with the starter fluid fertilizer where tighter rotational cropping of similar varieties is occurring. And of course foliar applications of nitrogen, micronutrients and herbicide mixtures can also be applied. Many options are available and they are only possible under the liquid regime.

Improve yields

The first five points mentioned above are all very good reasons why liquids have the ability to improve yields. When the problems of P fixation in the highly calcareous soils of South Australia are considered combined with several years of data indicating significant yield increases under liquid P programs, then the results are conclusive. Liquid P does improve yields.

Easy to use

Fluids are readily moved by pumping. Volumetric flow meters accurately measure volume. A minimum of time and energy is involved in transfer operations. More hectares per fill can be achieved at seeding time.

Product uniformity

Uniform composition and hence quality control, is readily achieved with liquid fertilizer. Maintaining desired pH and specific gravity for a product or grade characterises properties of fluid fertilizer assuring the chemical consistency of each batch.

The unique aspect of liquids is that with a mix of nutrients combined in a liquid form it can be assured that every drop has the same nutrient ratio as the next.

Easily adapted

Current day seeding machines in Australia are easily adapted to facilitate liquid use. Whilst all seed and fertilizer carts are currently adapted for dry blend fertilizers, adaptation to fluid systems is mechanically simple and can be done at low cost. It is then advantageous to fill the original box with seed and add a liquid cart to the rig to provide a liquid source.

Environmentally responsible

Phosphorus in the liquid form is between 2-5 times more useful as an available source of P than the alternatives. So less nutrients need to be applied to grow the same amount or more of crop dry matter.

LIQUID USE IN AUSTRALIA AND ITS FUTURE

The use of liquid fertilizers in the more intensive horticultural and irrigated cropping enterprises is well established in Australia and the fertigation of these crops very successful. However liquid phosphorous fertilizer use in broadacre crop production is limited in Australia. Even though there is a thirst for knowledge on the techniques and the source of using liquids, progress in liquid phosphorus use is slow.

In contrast to this the use of liquid nitrogen (urea ammonium nitrate) has increased at a rapid rate recently. The rapid adoption of UAN does appear in regions where UAN is manufactured and therefore undesirable freight rates do not have a negative influence.

As explained earlier the issues surrounding liquid N are different to liquid P, however North American models shows that growth in the use of liquid phosphorus fertilizers occurs after and on the back of liquid nitrogen use.

Whilst I have highlighted in this report the many advantages in using liquids, the industry in Australia does face a few challenges. The biggest of these is price. The price of mixed fertilizer solutions in Australia, in particular ammonium polyphosphate is very high. These are not manufactured in Australia and so the need to import these products from North America, South Africa or Russia creates a freight component to the price that is near equivalent to the price of the product. The high ambient temperature range that dominates Australia's autumn is also a problem and can compromise the quality of the polyphosphates (ie.tending to hasten the conversion of polyphosphate to orthophosphate) in the lead up to Australia's winter cropping program.

We know that liquid P is 2-5 times more available than alternative forms, however its high price is still driving farmers to apply rates lower than they would like. This application of very low rates because of the high price per unit of P is also limiting the growth of liquids. Their potential to increase yields and improve the economic basis of farming is therefore being limited.

Another challenge we face in Australia is finding the appropriate mix of liquids to meet our needs. With the need for trace elements (especially zinc) high through South Australia, finding an available and cost effective nitrogen, phosphorus and trace element mix is still proving to be a challenge.

CONCLUSION

Traditional wisdom would have us believe that a kilo of nitrogen is a kilo of nitrogen, a kilo of phosphorus a kilo of phosphorus and that fertilizer rate is more important than source or placement. We now know that this is just not true. There is absolutely no doubt that fertilizer rates can mask some inadequacies, however to continually increase rates can only be economically responsible up to a point.

On calcareous soils it is possible to increase phosphorous rates in the granular form to exorbitant levels and still not even mask some of this soil type's inadequacies.

Source and placement are the two defining parameters. That is applying liquid phosphorous in a continuous band to the root zone is the "shining light" for improving cropping yields in the high pH calcareous regions of Southern Australia. Lesser parameters are those surrounding nitrogen form and placement and the mix of other elements.

The important factor to consider though, is the whole fluid package of nutritional and management advantages that individual growers must deliberate over as they strive for continual improvement in crop production.