

Fluid JOURNAL

Official Journal of the Fluid Fertilizer Foundation

Fall 2011 • Vol. 19, No. 4, Issue # 74



Zinc: A Key Nutrient

Inorganic vs. Organic Fertilizers

How To Enhance Grain Yields

Going on Nineteen Years of Archives!

The Fluid Journal, flagship publication of the Fluid Fertilizer Foundation (FFF), makes nearly two decades of archives available on its web site. The magazine investigates and informs its readers on innovative uses of fluid fertilizers under varied cultural, pest control, and water management practices, focusing on evaluating:

- *the agronomics of fluid fertilizer in the production of maximum economic crop yields*
- *application techniques for fluid fertilizers*
- *the efficiencies and conveniences of fluid fertilizer systems*
- *methods of controlling environmental problems with fluids.*



Since its formation, the FFF has funded over \$3 million in fluid fertilizer research and accumulated thousands of pages of research data. The main goal of the Fluid Journal is to transfer this technical information into easy-to-read form to its farmers and dealers.

The Fluid Journal also provides links to its articles on Twitter
<http://www.twitter.com/fluidjournal>

For information on how to become a member of the FFF, contact the foundation's office at 785/776-0273 or the foundation's website: <http://www.fluidfertilizer.com>

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The Fluid Journal is published by the Fluid Fertilizer Foundation. The FFF is a non-profit organization committed to researching and providing information about fluid fertilizer technology. Since its formation, the FFF has funded over \$3 million in fluid fertilizer research. We have accumulated thousands of pages of research data. The main goal of the Fluid Journal is to transfer this technical information into easy to read form to farmers and dealers so they may be better informed as to the technological advancements that the fluid fertilizer industry has achieved.

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FROM THE PUBLISHERS

Why fluids?

Many of us have often been asked, “Why fluids?” In answering that question, the advantages of fluid placement, nutrient use efficiency (NUE), and overall crop profitability are often noted. Over the past decade, environmental protection and sustainability have also been used when describing the advantages of fluid fertilizers.

Over the past several years another term has come to the forefront in regard to environmental protection and sustainability: 4R Stewardship. At the mention of this, fluid fertilizers should immediately come to mind. This concept, initially developed by the International Plant Nutrition Institute (IPNI), is increasingly being adopted by agriculture as a way of promoting and communicating fertility-related best management practices (BMP) to the public, agribusiness, and farmers. While the promotion of fertility BMPs is certainly not new, the 4R Nutrient Stewardship concept provides a clear, concise, and simple approach to increasing the adoption of BMPs in agriculture by applying the appropriate rate of crop nutrients in an efficient manner, at the right time, using crop nutrient products that are right for a specific situation.

The 4Rs

What do the 4Rs have to do with fluid fertilizer? Everything! Fluids are uniquely

suitable for fertility programs based on the 4Rs:

Right rate. Determining the right rate of applied nutrients to meet specific crop needs is challenging and varies among needed crop nutrients. While a good soil test history and accurate crop records are needed for estimating the rate of nutrients required for a specific situation, there are other factors to consider. For example, research continues in developing nitrogen (N) fertilization systems that depend on various crop canopy sensors to estimate the right rate of in-season N required for fields and portions of fields. Fluid N products, such as UAN solution, are the obvious choice for this system.

Right time. There has been much emphasis placed on supplying needed nutrients, especially N, immediately prior to when the crop requires them. By minimizing the amount of time between nutrient application and crop nutrient uptake, the susceptibility of applied nutrients to off-field movement or losses to the environment is minimized. Fluid fertilizers excel in their adaptability to sidedress, topdress, and split/multiple applications via application equipment and various irrigation/fertigation systems.

Right place. Mention fertilizer placement and most people think of fluid fertilizers (e.g., preplant subsurface banding, sidedress subsurface banding, surface banding, surface dribble

application, in-furrow application, starter application, foliar application, fertigation, drip irrigation, and broadcast application). Fluid fertilizers are easily adapted to all of these application methods, while other forms of fertilizer generally are not.

Visit with researchers who study various crop nutrient application methods. Most likely, fluids are used for all the comparisons due to the ease and cost of adapting equipment to various placements.

In addition to versatility of fluids in developing efficient fertility programs, fluid products are homogeneous and provide the correct mix of nutrients in every drop. Segregation is not an issue. Likewise, fluid fertilizers provide for greater precision and accuracy in application rates than other forms of crop nutrients.

Right source. The versatility of fluid fertilizers offers growers the certainty that the BMPs embedded in the 4R concept will produce nothing less than stewardship, productivity, and profitability. The Right Rate, Right Time, and Right Place for required crop nutrients all point to fluid fertilizers being the Right Source.

So...when someone asks, “Why fluids?” the answer should be simple: Versatility. Flexibility. Efficiency. Placement. And the 4Rs of nutrient stewardship!

Dr. Dale Leikam
President,
Fluid Fertilizer Foundation



Technology Workshop

Sponsored by Fluid Fertilizer Foundation



The 2011 Fluid Technology Workshop to be held December 6-7 at the Piccadilly Inn Airport, 5115 E. McKinley, Fresno, CA 93727.

The Workshop provides an educational and networking opportunity for both experienced and less experienced personnel. Note that plant operations, agronomics and fluid fertilizer fundamentals are covered during the sessions.

To enroll, call 785-776-0273 or email fluidfertilizer@sbcglobal.net

Part 1 Zinc: A Key Nutrient in Crop Production

Zinc deficiency represents a common micronutrient deficiency problem in human populations.

Dr. Ismail Cakmak

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2011 • Vol. 19, No. 4, Issue # 74

Summary: It is estimated that zinc (Zn) deficiency affects, on average, one-third of the world's population and is known to be the major reason for high incidence of micronutrient malnutrition in human populations. Soil Zn deficiency is also an important constraint to crop production and nutritional quality of grains. Based on a range of studies, the average concentration of Zn in whole grain wheat in various countries ranges between 20 to 35 mg Kg⁻¹, which is inadequate for human nutrition. Evidence is available showing that seedlings derived from seeds with low concentrations of Zn are highly susceptible to biotic and abiotic stress conditions during seed germination and early growth stages. These results indicate that improving Zn concentration of seeds/grains is also important for better agronomic performance of seedlings. Additionally, biofortification of food crops with Zn is considered a useful intervention against problems in human nutrition by using agricultural tools such as breeding and fertilization. Biofortification strategy is also proving highly promising as a cost effective and long-term solution to Zn deficiency in human populations. Developing new Zn-dense genotypes by using plant breeding, however, takes a long time. The success of a breeding program depends on a sufficient amount of readily available pools of Zn in soil solution.



Zinc has particular physiological functions in all living systems, such as:

- Maintenance of structural and functional integrity of biological membranes
- Detoxification to highly toxic oxygen-free radicals
- Contribution to protein biosynthesis and gene expression.

Among all metals, Zn is needed by the largest number of proteins. Zinc-binding proteins make up nearly 10 percent of the proteomes in eukaryotic cells, indicating that at least 2,800 proteins are Zn dependent. About 36 percent of the eukaryotic Zn proteins are involved in gene expression. Its deficiency, therefore, results in diverse impairments in biological systems.

Zinc deficiency represents a common micronutrient deficiency problem in human populations, resulting in severe impairments in human health. Major health complications caused by Zn deficiency include:

- Impairments in brain function
- Weakness in immune system to deadly infections
- Alterations in physical development.

Zinc deficiency is known to be responsible annually for deaths of nearly 450,000 children under age five. Analyses under the 2008 Copenhagen Consensus identified Zn deficiency, together with vitamin A deficiency, as the top priority global issue.

It is estimated that Zn deficiency affects, on the average, one-third of the world's population, ranging from 4 to 73 percent in different countries. Low dietary intake is known to be the major reason for the high incidence of Zn deficiency in human populations, particularly in those regions where soils are low in available Zn and cereal grains having low Zn concentration are the major source of calorie intake.

Soil Zn Deficiency

Soil Zn deficiency represents an important constraint to crop production and nutritional quality of grains. Nearly half of the cultivated soils are affected by low levels of plant available Zn, especially calcareous soils of arid and semi-arid regions. Major soil factors resulting in adverse impacts on solubility of Zn in soils include high pH, low organic matter, low soil moisture, and high metal oxides with large fixing capacity for Zn (Figure 1).

Concentration. Since food crops,

particularly cereal crops, are inherently low in grain Zn concentration, growing them on potentially Zn-deficient soils further reduces Zn concentration of food crops and thus dietary intake of Zn by human populations. Based on a range of reports and survey studies, the average concentration of Zn in whole grain wheat in various countries ranges between 20 to 35 mg kg⁻¹, which is not adequate for human nutrition with Zn. Same situation applies to rice and maize, which contain even less Zn than wheat. In the case of Zn deficient soils, the reported Zn concentrations for wheat are much lower and range between 5 to 15 mg kg⁻¹. These values indicate high urgency of biofortification of food crops with Zn.

Yields. Soil Zn deficiency has severe impacts on crop yields. In certain regions with very low plant-available Zn in soils (DTPA-Zn around 0.1 mg kg⁻¹), cereal production is not economical, thus Zn fertilization is necessary to obtain a proper yield. As shown in Central Anatolia, application of Zn fertilizers in such soils enhances grain yield by a factor of 6 to 8 to around 2,000 kg ha⁻¹. In general, soils containing less than 0.5 mg DTPA-extractable Zn are considered

potentially Zn deficient that may respond well to Zn fertilizers. Low concentration of Zn in seeds also has negative impacts on growth of plants in Zn deficient soils. Evidence is available showing that seedlings derived from seeds with low concentrations of Zn are highly susceptible to biotic and abiotic stress conditions during seed germination and early growth stages.

These results indicate that improving Zn concentration of seeds/grains is also important for better agronomic performance of seedlings. Seeds with high nutrient density, especially with micronutrients, contribute greatly to better agronomic performance of seedlings, besides its positive impacts on human nutrition. In the future, particular attention should be paid, therefore, to routine seed analyses for composition of mineral nutrients. Harvesting seeds with high nutrient density represents an important challenge for both better human nutrition and better seedling vigor.

Problem solving

Supplements. Currently, various strategies are being discussed to alleviate Zn deficiency as it relates to problems in human nutrition. Giving Zn supplements to the target populations or fortification (artificial enrichment) of foods with Zn is considered one useful intervention against the problems. Although these approaches are effective in reducing the extent of the problem, these are not always affordable long-term nor easily accessible to target populations living in rural areas of developing countries.

Plant breeding. Alternatively, agriculture offers simple and cost-effective solutions to the problem. Plant breeding and agronomy represent cost effective strategies to alleviate micronutrient malnutrition problems by increasing grain concentrations of micronutrients and their daily intake through diets. It is well-documented that plant genotypes are highly different in use of poorly soluble sources of micronutrients in soils and translocation of micronutrients into grain. For example, in case of Zn, genotypes of a given crop species show impressive genetic variation for Zn accumulation in grain, especially wild and primitive forms of food crops. Such large natural variations in seed concentrations of Zn can be exploited under breeding programs to improve modern cultivars with high concentrations of Zn (e.g., genetic biofortification). The genetic biofortification strategy is a highly

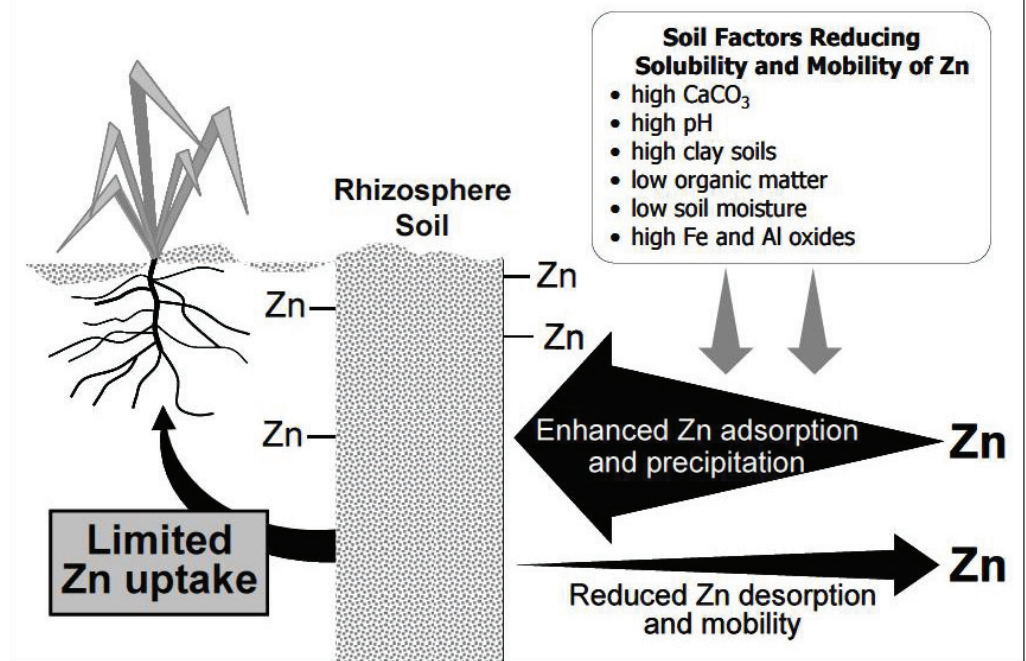


Figure 1. Main soil factors affecting solubility and root uptake of Zn in soils (Cakmak, 2008).

promising, cost-effective and long-term solution to Zn deficiency problems in human populations. Currently, impressive progress is being made under different breeding programs in improving stable food crops with high concentrations

“Improving zinc concentration improves seedling performance.”

of micronutrients, especially under the HarvestPlus program (www.harvestplus.org), which is established under the Consultative Group on International Agricultural Research. The Harvest Plus program uses plant breeding tools to improve stable food crops with Zn, Fe, and vitamin A, and to contribute to human health globally. The main sponsor of this global program is the Bill and Melinda Gates Foundation.

Cultivars. Developing new genotypes by using the plant breeding approach takes a long time however, plus the success of a breeding program depends on a sufficient amount of readily available pools of Zn in soil solution. High Zn deficiency incidence in human populations is observed mainly in the regions where soils are very low in plant-available (chemically soluble) Zn. The majority of cereal-cultivated soils globally has a number of adverse soil chemical factors (i.e., high pH values, low soil moisture, and low organic matter) that can potentially diminish the expression

of high grain Zn trait and limit the capacity of newly developed (biofortified) cultivars to absorb adequate amounts of Zn from soils and accumulate in grain. For example, among the soil chemical factors, soil pH plays a decisive role in chemical solubility and root uptake of Zn. In a pH range between 5.5 and 7.0, Zn concentration in soil solution is decreased up to 45-fold for each unit increase in soil pH. This increases risk for inducing Zn deficiency problems in plants and leading to low yield and simultaneously low Zn concentrations in grain.

Increasing cultivation of high-yielding cultivars may further contribute to the extent of Zn deficiency in soils by progressively depleting available soil Zn pools. This depletion of available Zn pools by large off-take in agricultural produce may occur to a greater extent in soils with low Zn solubility. Intensification of farming by introducing high-yielding cultivars contributes not only to Zn depletion in the soil but also to dilution of Zn in the harvested parts of plants such as seeds/grains. Increasing evidence is available showing that selection of modern cultivars with high yield capacity over more than 100 years caused a clear decline in grain concentrations of minerals, especially micronutrients.

This is Part 1 of a two-part series. Part 2 will appear in the Winter 2012 issue and cover Zn fertilizer strategies for improving yield and grain Zn concentrations.

Dr. Cakmak is a Professor at Sabanci University, Istanbul, Turkey.

Science Is On The Side of Inorganic vs. Organic Fertilizers

Striking examples of desperately needed yield increases in Africa and Asia offer solid proof, not pipedreams.

■ Dr. Terry Tindall

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2011 • Vol. 19, No. 4, Issue # 74

Summary: *The recognizable solution may rest in the ability to produce more, healthier plants on less land than we have been able to accomplish in the past. It has been estimated that a total of 30 percent of cereal production worldwide has been attributed to fertilizer inputs. Nitrogen (N) alone has increased small grains by over 20 percent. Since the mid-1960s, 50 to 75 percent of the crop yield increases in Asia have been attributed to inorganic fertilizers in combination with local supplies of organic matter such as manure. By withholding N, corn production in the U.S. was estimated to be reduced by over 40 percent and rice production by almost 30 percent. It is little wonder then that the U.N's World Food Organizations (FAO) embraces the use of inorganic fertilizer as an essential part of food security and feeding the world's burgeoning societies. On the other hand, it amazes one to hear others decry the use of inorganic fertilizers when the proof is they boost yields in many areas of the world that otherwise suffer food shortages, potential malnutrition, and droughts.*



Feeding a family in sub-Saharan Africa is a challenge even in areas where there are productive soils, adequate water, and a good growing season. Families struggle at lower wages and the vast majority (50 to 60%) of that income is spent on food. Zambia and Mozambique are good examples. Traditionally, small growers raise enough in small vegetable gardens to feed only themselves, with a small portion to share with neighbors within their villages. "Things have improved," says Marymey Jossan from the Kafu River area of Zambia. "As a child, we suffered much greater hardships. Our gardens failed to provide my family with enough food for ourselves, let alone anyone else." Mary still struggles. But allowing advances from developed countries to influence the lives of others is improving food sustainability. Yet many people in these countries face hardships. The average life expectancy in many places in South Africa is less than 40 years of age. The question is where can we help? Obviously appropriate improvements in knowledge, inputs, and resources need to be explored and put into place to improve some of the basic

opportunities of life. In this regard, there are certain cornerstones that must be met.

Stability. A country's ability to sustain itself and create an environment of peace and stability is based in great part on its capability to feed itself. As a nation's population grows and develops these same obligations increase. The absence of limitations being placed on any nation as it works to accomplish this basic responsibility inevitably will invite an environment of instability and potential chaos. The goal, and the way out of this obviously, is food security. Or more properly defined: stability, where all people at all times have both physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life. If these conditions do not exist--where this type of access is not met and sufficient food is not available--then food insecurity simply exists. Among the culprits causing this may be:

- Lack of productivity
- Lack of knowledge to improve productivity

- Insufficient funds to purchase food
- Governmental limitations on food accessibility or distribution.

Another frightening trend that could rattle world stability is a report by the United Nations Food and Agricultural Organization (FAO) that undernourishment will remain high through 2011. When global food prices--as a result of fertilizer, seed, water delivery, and other associated input costs--show a sharp rise there is inevitably a corresponding concern for food unavailability, further dampening any feelings about food security.

Population. Population increases are undeniable and with those projected increases will come more demand for crop production on less and less available land. The expected increase in population, by some estimates, is projected to be greater than 38 percent by the year 2050. This will put enormous pressure on the world to provide for its food needs, some projections showing up to 9 billion people. It becomes a huge responsibility to provide both food and fiber to provide for the needs of this type of geometric increase. For those

who have traveled to Asia, India, the Philippines, and parts of Africa, these numbers speak volumes in areas where higher resource inputs are required to sustain the needs of the ever-increasing populations and a hungry world. Even conservative estimates acknowledge that more being produced on limited arable land will have to be accomplished to meet world demands. Distribution of resources from one location to another will be a part of this, but that alone is not enough. Many from FAO have estimated that a combination of improvements needs to be used to address these concerns. They could include:

- Producing more on land already in production
- Open up larger tracks of land that are not currently being accessed
- Improve water delivery programs to marginal lands to increase production capacity.

But increasing arable land is not that simple. Accessing that which is available within South America or Africa has problems. Infrastructure in both locations is not in place and to develop it could be a political challenge as well as an environmental hurdle that could stand in the way of this process. However, China is developing an urbanization plan that involves moving smaller villagers into more concentrated cities while at the same time moving forward to develop this resource of available land to improve food security. While these policies may seem harsh, they can be effective. They would be harder to implement in other areas of

the world.

The ultimate and recognizable solution rests in the ability to produce more healthier plants on less land than we have been able to accomplish in the past. Estimates show that 30 percent of cereal production worldwide can be attributed to inorganic fertilizer inputs. Nitrogen alone has increased small grains by over 20 percent. Since the mid 1960s, 50 to 75 percent of the crop yield increases in Asia have been attributed to inorganic fertilizers in combination with local supplies of organic matter such as manure. By withholding N, corn production in the U.S. dropped an estimated 40 percent. Rice production fell almost 30 percent. Small wonder, then, that FAO embraces the use of inorganic fertilizer as an essential part of food security and feeding of the world's burgeoning societies. One can only listen in amazement as there are those who disparage the use of inorganic fertilizers as one of the causes of droughts and low yields in many parts of the world.

The facts show otherwise. In long-term studies that have been conducted at several locations around the world, inorganic fertilizer combinations of NPK have increased yields between 50 to 80 percent. Such compelling responses can be implemented immediately on cropping systems of both small- and large-scale farmers anywhere. This includes many traditional areas as well as those lands that are being expanded more under increasingly intense production management strategies. It is not just the

NPK inputs that will be responsible for production increases, but a combination that will include secondary and in most cases essential micronutrients.

Sustainability

The Fluid Fertilizer Foundation supports the 4Rs of nutrient stewardship being promoted by several fertilizer organizations. Within the context is the right form of fertilizer. In many instance the right form may very well be an "enhanced efficiency" fertilizer. While not all are available in every area, many are. Research has been initiated in several emerging nations to take a closer look at how these types of enhanced fertilizers may create a more efficient delivery system that would have long-term benefits for improving development in traditional inorganic fertilizers. Enhanced efficiency fertilizers are available for both nitrogen and phosphorus.

Combination counts. Organic matter is also an essential component to productivity, and science supports this. To continue to improve food sustainability, a combination of organic matter management with inorganic fertilizer inputs creates an environment where long-term productivity can take place. These improvements in production allow food security to become a reality at a time and place where an ever-increasing population depends on what can be produced.

Dr. Tindall is senior agronomist at J.R. Simplot Company, Boise, Idaho.



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Needed: A Research-driven Understanding of Every Aspect of Producing Grain

A long-winded, kitchen sink approach to enhance grain yields and profits.

■ Dr. Timothy Maloney

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2011 • Vol. 19, No. 4, Issue # 74

Summary: *We have entered an age of amazing precision in agriculture. Not only does size matter, but with size comes performance and improved accuracy. We need to accept the reality of this fundamental shift in agriculture and respond with research driven by understanding every aspect of producing grain. Inputs are much more involved than just seed and pesticides. Knowledgeable genetic selection is just as crucial as knowing your costs. Another challenge is selecting the right equipment. And the list goes on. What about seeds and pesticides? Herbicides? Foliar fungicides and insecticides? And don't forget the soil. Finally, what about y-o-u-r skills? Are you an innovator, adopter, or follower? Bottom line: a skilled operator knows how to produce profitable grain.*

Far too often in life we have a natural tendency to focus on one item as the answer to a problem. However, reality teaches us that multiple factors usually contribute to the solution. In modern agriculture we face a similar dilemma. We may promote product A or product B as the yield enhancing miracle cure. Sometimes that is indeed true, but more often it is only part of the cure and modern agriculture demonstrates that reality.

Twenty-four row planters, Class 9 combines, and 600 horsepower tractors all point to the future or reinvention of grain farming. Three-hundred-bushel

“Know your costs of Everything!!”

corn needs to be the norm not the exception. We have entered an age of amazing precision in agriculture. Not only does size matter, but with size come performance and improved accuracy. We need to accept the reality of this fundamental shift in agriculture and respond with research driven by understanding every aspect of production grain. Factors of genetics, information, profitability, equipment, inputs/outputs and the soil, as well as honing our skills all must be a part of this reinvention.

Genetics

Genetics is the fundamental foundation of yield. Marketers often fixate that it is the GMO trait that produces yield. Actually, it is the agronomic and DNA traits that determine a potential yield. The GMO traits assist in protecting the yield potential. Additionally, seed selection based on yield, test weight, and grain dry-down are important, but we must also look at percent germination, seed

size, relative maturity, root size, stalk strength, stay-green, disease package, early season vigor, and population density. These additional factors must be identified to unlock the hidden yield potential in every hybrid/variety. Building upon our genetic selection includes our need to access information.

Accessing

Our sources of information may originate from:

- Seed and/or pesticide suppliers
- Custom applicators
- Farm service agencies
- University extensions
- Friends and neighbors
- And don't overlook the internet!

Such accurate and timely information will assist producers in their pursuit of higher yields. And while we often use yield as the sole source of success in what we do, we would be remiss if we did not also factor in profitability.

Profitability

Cost of inputs versus expected outputs, cost per acre, cost per bushel, profit per bushel, and profit per acre all must be calculated to help producers to market their products. Knowing your costs signifies knowing the cost of everything:

- Land costs:
 - Rents
 - Leases
 - Mortgages
 - Needed improvements
- Costs of:
 - added fertilizers
 - pesticides
 - seed and seed additives
 - fuel



- equipment
- maintenance
- labor

All must be known to maintain profitability. Throughout the growing season any additional applications must be calculated as to what impact it would have on yield and profitability.

Equipment

We know equipment is easy to access. Simply put: choose a color, find a dealer, pay the money, and you get the equipment. It is the challenge of choosing the correct type of equipment, how to use that equipment, and how to properly drive and maintain that equipment that creates more anxiety. The range of our equipment needs includes:

- Tractors
- Planters
- Tillage pieces

- Sprayers
- Applicators
- Combines

Tractors. Regarding tractors, it is important to relate tractor power to wheel slip, to soil compaction, to fuel economy and so forth.

Planters. We have made great improvements in our planters, much with respect to their increased size and improvement in efficiency. Planters do, however, require maintenance and attention to detail to maintain optimum performance.

Losses in potential grain yield can be significant due to skips, doubles, and poor stands. Follow strict guidelines regarding wear tolerances on coulters, seed openers, tubes, seed meter brushes, as well as proper tire inflation.

Other yield factor enhancements involve slower planter speeds (4 to 4.5 mph), and proper seeding depths (2 to 2.5 inches). Remember, stand uniformity is the key to producing high yielding corn. Maintain your equipment to assure success in this area. Everything we do to a crop later in the season reflects on starting right!

Combines. And what about the combine? Sadly, the combine often gets forgotten as a machine that can be made more efficient. Many are able to drive a combine. However, few understand combines well enough to operate without higher than necessary grain losses. A productive combine requires adjustments

throughout the harvest season.

Inputs

Inputs are much more involved than just seed and pesticides. Inputs include seeding rates, row spacing, fertilizers, as well as adding herbicide and insecticide traits to them.

Fertilizers include not just the formulation, but also the type and timing. Considerations of fertilizer loss due to volatilization and denitrification as well as through surface runoff may encourage producers to apply their fertilizer in different forms and at different timings to more effectively match crop needs. Matching crop yields to fertilizer needs plus application timing may also encourage the use of starters, in-season sidedress application, as well as adding micronutrients to soil, or via foliar sprays.

Herbicides. What about them? We know that glyphosate is the standard, but with the threat of weed species shifts and/or potential resistance issues we may need to revisit the need to use a variety of modes of action to maintain weed-free fields. Likewise, it is important to understand the activity of any herbicide class, plus any additives in the mix, to understand how the crop will respond. Hidden yield losses are always possible.

Fungicides/insecticides. Use of foliar fungicides and/or insecticides is a hot topic. Are they necessary? Do we spray in the absence of visual symptoms and spray for plant health? Accurate answers

include the use of crop scouting and understanding the impact of your crop.

Closing tips

Do not forget the soil. All crops require 16 essential nutrients--however, at different levels. Yet, even in a soil with

“Are we innovators, adopters, or followers?”

good fertility levels a soil with low or high pH may not provide a proper level of available nutrients.

Finally, our skills reflect on our ability to pull it all together. Are we innovators, adopters, or followers? The category we find ourselves in can determine our levels of success. A skilled operator knows how to produce profitable grain!

Knowledge counts

So, it may be a gross exaggeration to say farming is simple when we know better. Modern grain production is an expensive business that requires high-tech inputs in the hands of knowledgeable people. If all that was required would be to grow 100-bushel corn, most could do that with their eyes closed. In the future, the level of expectation may be to produce 300- to 400-bushel corn. To produce corn at that level will involve close scrutiny of every aspect of a producer's operation, not just those on the surface.

Dr. Maloney is a Production Research Agronomist and owner of Agri-Tech Consulting in Whitewater, Wisconsin.

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The Concept of Fluid Fertilizers May Well Date Back to 1808

An Englishman by the name of Humphry Davy successfully used dilute ammonium acetate in a field of wheat.

■ **Did you know?**

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Shortly after 1799 when Sir Joseph Banks and American-born Count Rumford founded, what became a year later, the Royal Institution in London, they appointed Humphry Davy as their first resident lecturer. He proved to be an outstanding researcher, always fulfilling his responsibilities.

In 1802, early in his lectureship, he was requested by the Board of Agriculture to direct his attention to agricultural subjects. The following year he instituted a course of eight lectures that he repeated over the next decade.

In 1810, his sponsors invited him to publish the text of his lectures as a monograph entitled "The Elements of Agricultural Chemistry."

In general, his lectures tended to be oriented toward arable farming systems and dealt largely with the nature of crops and soils. Conventional crop husbandry and the associated environmental factors were mentioned but the main emphasis was on the chemistry of available plant nutrients. One complete lecture would be devoted to animal and vegetable manures and another to mineral or fossil additions.

Enter fluids

Davy referred to the different organic manures already in regular use and the way they were transformed by fermentation and putrefaction. He discussed how they could be mixed and the most appropriate way they should be handled and applied. He noted that there was a considerable risk of losing both liquid and gaseous components, which he referred to as "potential nourishment of plants." To demonstrate this, he placed hot cattle manure in a retort and collected the condensable fluids in a receiver during a period of three days. When he analyzed the content of the receiver, he detected ammonium acetate and carbonate. He repeated this experiment with a slight variation, describing it as follows:

"I introduced the beak of another retort filled with similar dung, very hot at the



time, into the soil amongst the roots of some grass in the border of a garden. In less than a week a very distinct effect was

"Davy's work contributed much to the world of fluid fertilizers."

produced on the grass upon the spot exposed to the influence of the matter disengaged in fermentation. It grew with much more luxuriance than the grass in any other part of the garden."

There seems little doubt that the experiment is probably one of the very earliest recorded instances of the injection of gaseous ammonia into the soil supporting a growing crop--well over a century before its adoption in the United States in the 1930s.

Fine tuning. Although the application of organic manures, including urine, had been a well-established practice since the Middle Ages and even earlier, Davy seems to have been one of the first to offer a rational explanation of the nature of the "nourishment" they contained. He was also conscious that such "nourishment" was taken up by plants in

the aqueous phase, so this led him to a series of experiments to determine the effect on plants of a range of dissolved substances, including many inorganic compounds derived from mineral sources.

Although in the 17th century Sir Kenelm Digby had watered barley with a dilute solution of nitre and reported luxuriant growth, he did not appear to have appreciated its potential significance. Consequently, Davy tried on both grass and corn the effect of a range of solutions containing sodium, potassium, and ammonia as sulphates, nitrates, carbonates, chlorides, and acetates. He found that in all cases:

“...when the quantity of salt equaled one thirtieth part of the weight of water, the effects were injurious, but least so in the instances of carbonate, sulphate, and muriate of ammonia.”

Further dilution by a factor of ten made all the difference and he concluded:

“Plants watered with the solutions of sulphates grew just in the same manner as similar plants watered with rain water. Those acted on by the solution of nitre,

acetate, and super-carbonate of potassa, and muriate of ammonia grew rather better. Those treated with the solution of carbonate of ammonia grew most luxuriantly of all.”

Davy was somewhat puzzled by the results from ammonium nitrate solution as the growth was similar to that of plants treated with rainwater, but when he found that the solution was very acidic he concluded that the free acidity may have interfered with the result.

Subsequently, in 1801, he scaled up the more successful of his experiments when he was able to assist growth in a field of wheat by applying a dilute solution of ammonium acetate. He also made the point that soot, long known for its fertilizing properties, contained ammonium salts and deduced that the liquor arising as a byproduct from the destructive distillation of coal could be an abundant source of ammonia that could be used for agricultural purposes. Significant quantities of this so-called gas liquor were applied on a local basis. However, it was many decades before it

was officially recognized as a nitrogenous fertilizer.

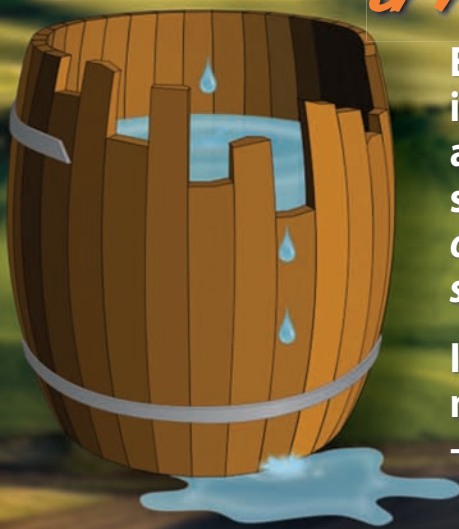
Gifted insight

Humphry Davy was an extraordinary individual with intuitive experimental skills, coupled with a flair for communicating his findings to his audiences in his Royal Institution lectures and elsewhere. Sir John Russell considered that one of Davy's major contributions was to establish Agricultural Science as a coherent subject. Russell claimed that Davy's "Elements of Agricultural Chemistry" reigned as the standard text of its field for over 50 years and that its contents were cited in 1840 by Justus Liebig in his well-known work in the same field. It was my privilege in 1974 to draw attention to Davy's remarkable insight into the way nutrients in fluid form were taken up by crops and the crucial role of nutrient concentration in optimizing crop response. It is further my privilege to be able to author this article in celebration of the 200th Anniversary of Davy's seminal work that contributed so much to the world of fluid fertilizers as we know it today.

Derek Palgrave, author, joined J.W. Chafer, Ltd. of Doncaster, England, in 1964 as its chief chemist and technical director. He is now involved in a program of public lecturing on a wide range of topics, including science and technology.

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FLUID FERTILIZER FOUNDATION: SOLUTIONS FOR AGRICULTURE

Founded in 1982, the Fluid Fertilizer Foundation has funded research resulting in significant advancements in fluid fertilizer application techniques and improved nutrient management systems. Each year, the Foundation works with 10-20 leading research teams on the development of innovative fertilization programs and continued improvement in crop yields. Then we make sure this information is passed on to you by publishing the research results in the Fluid Journal and through various educational programs sponsored by the Foundation!

What Is The Fluid Fertilizer Foundation?

The Fluid Fertilizer Foundation (FFF) is an industry funded research and education organization focused on taking advantage of the efficiencies, effectiveness and convenience of fluid fertilizers. The Foundation is a 501(c)(3) tax deductible organization.

What Is The Purpose Of The FFF?

The purpose of the FFF is to develop and advance innovative, profitable and agronomically sound fluid fertilizer application techniques and nutrient management systems for modern high yielding production systems.

The FFF accomplishes this mission by providing financial support for research focused on innovative uses of fluid fertilizers, disseminating research information to interested parties and conducting educational programs focused on agronomic and operational issues related to fluid fertilizers. Foundation.

How Does The Foundation Operate?

The Foundation is completely funded by member contributions and is run by a Board of Directors elected by the members. The Board is ultimately responsible for the overall operation of the Foundation. Management of the Foundation is on a contractual basis and there are no employees of the Foundation.

Educational programming and research projects are determined and developed by the Research & Education Committee – and the Research and Education Committee is comprised entirely of industry members.

Who belongs to the Foundation?

- Industry leaders from the U.S., Canada, Australia and other countries
- Crop input suppliers and Distributors
- Fertilizer manufacturers
- Associated industry suppliers
- Commercial laboratories
- Other organizations and individuals

The Fluid Fertilizer Foundation develops and advances fluid fertilizer programs for high yielding crop production through research, education and information dissemination.

For more information about membership in the Fluid Fertilizer Foundation, please contact us by phone, mail or Email.

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