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The International Nitrogen Initiative

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INTRODUCTION

Last year at the FIRT Annual Meeting, I gave a presentation entitled "Latest Developments Regarding Fertilizers and the Nitrogen Cycle: Implications for the Fertilizer Industry". A major element of that paper was a history of the International Nitrogen Initiative, which is the focus of my words today. Therefore, to avoid repetition, I refer you to that paper for any background information that you may require. In addition, I have brought some copies of a brochure describing the International Nitrogen Initiative (INI) with me.

The first question that we can ask is why so much attention is being focused on nitrogen. The answer comprises several parts.

As a starting point, let us recall that before the beginning of the 20th Century, there was virtually no artificially fixed nitrogen. Human intervention in agriculture included the spread of nitrogen fixing crops, but the industrial and technical processes that exist today were unknown, and this posed a serious problem for global food security prospects at that time. This explains why the Haber-Bosch process was considered so important that it earned not one, but two Nobel prizes.

Because the nitrogen cycle was in a state of natural balance before the advent of the Haber-Bosch process, it is not surprising that scientists did not foresee the negative consequences of disrupting this equilibrium. Starting around 1950, we started introducing an ever greater quantity of reactive nitrogen into the environment. Part of it was taken up by crops and has served humanity well in reducing global hunger. However, a large portion of the nitrogen applied to crops is not incorporated into food products and is accumulating in the environment.

The concept of accumulation is an essential element of why the nitrogen conundrum is so difficult. Unlike most elements, reactive nitrogen is persistent and cascades through many reactive forms before eventually being reconverted into the inert dinitrogen form. Therefore a single molecule of reactive nitrogen can contribute to several undesirable environmental impacts. These include reduced water quality, imbalanced ecosystems, climate change, urban ozone depletion and acid rain, among others. Consequences include effects on human health, reduced biodiversity in marine environments and degraded forests.

To be sure, fertilizer nitrogen is not the primary culprit in all of these phenomena, but more nitrogen is converted to its reactive form by ammonia synthesis than by any other process. One-half of the total synthetic nitrogen fertilizer ever produced has been used within the last 20 years, a period over

which the global average for nitrogen fertilizer use efficiency is estimated to be around 50 per cent.

INI: SEEKING TO MEET THE NITROGEN CHALLENGE

Humanity remains extremely dependent on reactive nitrogen and the fertilizers that contain it. We are all familiar with Vaclav Smil's calculation that 40 per cent of protein consumed from humans is derived from nitrogen fertilizer. It is estimated that the current population exceeds the natural limit of a non-fertilized world by about one-third.

Yet it is likely that we have only begun to see the impacts from the reactive nitrogen that has not been integrated into food products and is currently cycling through the environment in unprecedented amounts, with the effects mentioned earlier.

So the challenge that the International Nitrogen Initiative (INI) has set for itself is to determine how to optimize the use of nitrogen to sustain human life while minimizing the negative impacts on the environment and human health.

The participants of INI have determined that there are four types of instruments that can be applied to this challenge. Scientific means can help us better understand the pathways that reactive N follows and means for disrupting its cascade. Engineering can help us intervene to reduce the quantity of reactive N produced and to reconvert cascading N into its inert form. Social methods can help change individual behavior. Political measures will set the necessary framework and provide the positive and negative incentives for action to be taken. I would add a fifth instrument to the mix: economics. It is commonly stated in our industry that a major barrier to the spread of enhanced-efficiency fertilizers is their relatively high cost when compared to traditional products. If farmers also had to pay for the impacts of the relative inefficiency of traditional products, then the equation could become more favorable for products that incorporate technology.

It is not an either/or proposition. All of these instruments must be applied in an integrated way if we are to increase the rate at which nitrogen is incorporated into food products and reconvert excees reactive nitrogen into its inert form.

In keeping with this holistic view, INI employs a three-step approach that moves from scientific enquiry through the design of solutions to their implementation.

A REVIEW OF MAJOR OUTCOMES

Although I do not want to repeat everything I said last year, I would like to mention some of the major milestones to date so that the context for new developments is fresh in your mind.

The Nitrogen Fertilizer Rapid Assessment Project (NFRAP)

Supported by IFA, the Scientific Committee on Problems of the Environment (SCOPE) carried out a rapid assessment of the fate of fertilizer nitrogen in different contexts. This helped scientists to better understand the impacts of reactive nitrogen in agricultural milieux and appropriate responses.

The assessment looked at fertilizer use efficiency, the role of emerging technologies, the pathways through which N is lost, related impacts and, finally, societal responses.

The results of NFRAP were published by Island Press in a monograph entitled "Agriculture and the Nitrogen Cycle: Assessing the Impacts of Fertilizer Use on Food Production and the Environment". The Executive Summary can be accessed at www.initrogen.org/72.0.html.

Advanced Approaches to Quantify Denitrification

Noting that we have little knowledge about how much nitrogen is denitrified, when and in what location, INI organized a three-day workshop in 2004 to explore this topic. This event helped to improve methodologies for quantifying the N_2 production as a result of biological denitrification. The results of the workshop are in the Final Report (www.initrogen.org/73.0.html). More detailed scientific outcomes have been or will be published in a series of eight papers submitted to the journal *Ecological Applications.*

The Third International Nitrogen Conference

The Third International Nitrogen Conference, held under the auspices of the Chinese Academy of Sciences, placed particular emphasis on the situation in Asia. There were also several outcomes of global importance.

The INI Steering Committee presented a preliminary assessment of changes in the global nitrogen cycle as a result of human influences, which reviews what is known and unknown about the impacts of humanity on the nitrogen cycle and the consequences. That document is available at www.initrogen.org/fileadmin/user_upload/2005_products/INI_Pre-Assessment_final.pdf.

Another thought-provoking paper presented in Nanjing tried to quantify the costs and benefits related to current nitrogen fertilizer use and its potential reduction.

The final text of the conference – which gathered researcher from such diverse disciplines as agronomy, ecology, biogeochemistry, oceanography and atmospheric sciences, as well as other sciences dealing with agriculture, animal husbandry, forestry, fisheries and energy production – was the Nanjing Declaration. This document encourages international policymakers to address the nitrogen challenge.

WHAT'S NEW SINCE OCTOBER 2004?

The preceding list briefly summarizes events as of last October when we met in Annapolis. Now I would like to give you an overview of current activities.

Follow-up to the Nanjing Declaration

The document that emerged from the Third International Nitrogen Conference was, as a first step, forwarded to the Executive Director of the United Nations Environment Programme (UNEP) for consideration. The declaration was referenced during the preparation of UNEP's Global Environment Outlook (GEO) 2004 yearbook and was included in that document as a footnote. The European Union is submitting a draft decision to the UNEP Governing Council in February 2006 that urges action on global nitrogen management. IFA has been following the development of the decision closely in order to ensure that it addresses the issues and background in a balanced and constructive manner.

We anticipate that the issue will garner much more attention in policy circles once a formal UNEP resolution is passed, even if the text of drafts that we have seen is somewhat anodyne. However, an institutional resolution provides a "foot in the door", so vigilance is required, especially as we know that some parties favor the eventual development of an international protocol on reactive nitrogen, similar to what has been developed regarding carbon dioxide within the climate change context.

Convention on Biological Diversity

Alongside conventions on climate change and desertification, the Convention on Biological Diversity (CBD), was one of the major policy outcomes of the 1992 Rio Earth Summit. Its primary intention was to address the impacts on ecosystems created by human activities and to protect the Earth's biological diversity, for both ideological and practical reasons.

Because the accumulation or depletion of reactive nitrogen in an ecosystem can have destabilizing effects, this policy forum is likely to become much more relevant for our industry in coming years. The CBD uses nitrogen deposition as an indicator of change in the level of biodiversity in ecosystems, and the Convention's secretariat has asked INI to collaborate on this topic. INI is providing expertise on a number of technical aspects of the nitrogen indicator. The fertilizer industry will be particularly interested to note that INI has been requested to consider integrating phosphorus into its analyses, notably with regard to the flow of these nutrients through wetlands and rivers, as well as their relationship to harmful algal blooms and so-called dead zones in the ocean.

Consequences of Industrial Animal Production

The International Nitrogen Initiative intersects with another SCOPE project on the Consequences of Industrial Animal Production or CIAP. This project is currently studying the implications of increased consumption of meat, eggs and milk for the trade in virtual water, energy and nutrients. Briefly, the concept is that any time feed, meat, milk, etc. are transported across borders, the water, energy and nutrients they contain are also traded. Once these products are consumed they create waste streams that therefore constitute another local source of nutrients, for example, that needs to be included in any sort of integrated management scheme. We know how fertilizer nutrients are transported around the global, but once these nutrients are incorporated into food or feed, we have little information about their further movement. Anecdotal evidence indicates that these flows are currently aggravating the concentration of nutrients in some locales and their depletion elsewhere.

Issues related to nutrient cycles will be integrated into a major conference on "Livestock in a Changing Landscape" at the end of 2006. The Food and Agriculture Organization (FAO) of the United Nations and SCOPE will be major partners. A workshop on the contribution of animal production to alterations in the N cycle will be held as a follow-up to the livestock conference.

ACTIVITIES AT THE REGIONAL LEVEL

INI is currently comprised of five regional centers, with momentum building for the establishment of a sixth in South Asia.

Not surprisingly given the constraints under which they operate, the African and Latin American centers are still in the process of building a solid foundation for their activities. As a general rule, the INI centers are hosted by existing universities or similar institutes and the designation as an INI center does not necessarily mean additional resources becoming immediately available. Nonetheless, a number of activities have been carried out in each of these regions with regard to INI.

Scientists active in INI have made presentations at key crop science conferences in Africa, and the January 2004 NFRAP workshop was held in Uganda. A preliminary assessment of the nitrogen flows in Africa has been launched. Several other presentations and events have been held or are under preparation.

The Asia center was obviously linked to the Nanjing Conference, which was complemented by a

Sino-Japanese workshop on major nutrient cycling in agroecosystems. A preliminary assessment of reactive nitrogen cycles in Asia has been completed. Papers from the first Indian workshop on nitrogen can be found at www.ipuniversity.nic.in/scon/nitrogen.html.

The major development at the European center has been the launch of a project entitled "The nitrogen cycle and its influence on the European greenhouse gas balance" (NitroEurope or NEU for short). The projected has received a total of €16.6 million euros, partially from the European Commission and will officially get underway in February 2006. IFA is a member of the External Advisory Committee. More information can be found at www.neu.ceh.ac.uk.

Because it grew out of the former SCOPE Nitrogen Project, the North American center has a strong institutional base. It works as a consortium of interacting projects. Bob Howarth of Cornell University is its director, and up-to-date information on the North American regional center can be found at www.eeb.cornell.edu/biogeo/nanc/nanc.htm.

With regard to Latin America, several workshops have been held across the region, and a preliminary assessment has been carried out for one area of Brazil. The Fourth International Nitrogen Conference will be held in Brazil in 2007, and arrangements are currently being made.

WHAT LIES AHEAD?

At the moment, international nitrogen planning is focused on three events.

A gathering of relevant policymakers and scientists is being organized with the UNEP Division for Technology, Industry and Economics in early 2006. Partial funding has been obtained. The goal is to unite stakeholders that regularly work on the nitrogen issue in an attempt to identify the best areas to move forward in the policy arena.

A second planned workshop will look at the effects that human activities are having on marine environments through the creation of reactive nitrogen. The focus will be on the open ocean, which is less studied than coastal systems. The necessary funding for this meeting appears to be coming together quite easily.

A third workshop on the beneficial and negative interactions between reactive nitrogen and human health is planned, but there have been difficulties establishing links with the medical community.

CONCLUSIONS

In conclusion, momentum is clearly building around the challenge of managing the reactive nitrogen present in the environment in such a way that we can continue to ensure adequate food production while minimizing unwanted impacts. There is no disputing that reactive N is accumulating in the environment and is increasingly concentrated in a number of places, while others suffer from a cruel lack of the same reactive compounds.

Opportunities for the fertilizer industry to engage at the national, regional and international levels are plentiful and multiplying. IFA's experience to date shows that it is important to seize these changes. Our collaboration with the scientific community has been largely constructive thus far. However, the train will not sit in the station waiting for the industry to board. If we do not join the architects of a global nitrogen management regime, we will have one imposed upon us. It is therefore desirable for the industry to mobilize at every level. This is especially true as the interactions between reactive nitrogen and the cycles of other fertilizer elements, notably P, are emerging.