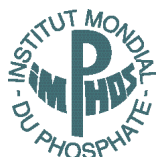




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IMPHOS TODAY

Regional research network on fertilizer management for crop production on the acid-sulfate soils

The acid sulfate soils represent a considerable land area in Asia (18-20 million hectares), mainly in **China, Cambodia, Indonesia, Malaysia, Thailand, and Vietnam.**

Acid sulfate soils develop as result of wetting and drainage of parent materials that are rich in pyrite (FeS_2). This accumulates in waterlogged soils that are rich in both organic matter and dissolved sulfate from seawater flushing. When drainage brings oxygen into previously waterlogged soils, the pyrite is oxidized to sulfuric acid. As production of the acid exceeds the neutralizing capacity of the parent material and the soil pH levels fall below 4, the acid-sulfate soils are formed. As such, approximately 1.8 million ha of acid sulfate soils occur only in Vietnam, of which about 80% are under rice cultivation.

To design a strategy for sustainable crop production on acid sulfate soils, there is a need to test and experiment during several years of production technologies that will overcome the multiple constraints of these production environments. The World Phosphate Institute designed an experimental field research that is intended to improve our understanding and ability to convert these soils into productive ones. By the end of it, useful recom-

mendations are expected on the best profitable and agronomically effective applications of phosphate rock (PR). The project covers five countries (China, Indonesia, Malaysia, Thailand, and Vietnam) and is implemented in collaboration with CIRAD. To the extent possible, distinction was made between potential and actual acid-sulfate soils, and four objectives were set out:

- To improve rice yield on acid-sulfate soils through good fertilizer management.
- To improve phosphorus nutrition of crops, especially flooded rice.
- To track any durable changes in soil fertility and phosphorus status in particular.
- To study the economics of fertilizer use on acid-sulfate soils.

In each country, soil samples were taken for analysis of the main soils parameters and in order to select the appropriate experimental sites and assess the rate of phosphorus to apply.

In each of the five countries, three types of phosphate rocks (PR) of different solubilities as measured in commonly used reactants are tested with particle size of 100% passing through 100 μ screen. (*continued on p. 2*)

Integrated plant nutrient management

«Integrated Plant Nutrient Management» or IPNM is the topic of a symposium held in Islamabad on November 8-10, 1999, and co-organized by NFDC, FADINAP and FAO in collaboration with Federal and Provincial Institutes and the Soil Science Society of Pakistan. It was an opportunity for the IMPHOS coordinator of Asia program to elaborate on «IMPHOS Contribution towards Sustainable Nutrient Management in Asia»

Based on the deliberations of the symposium, the following recommendations were drafted for the intention of policy planners, researchers and farmers, in advocacy of an integrated nutrient

management approach in Pakistan:

● Inorganic fertilizers have played and will continue to play a key role in plant nutrition, but because of their imbalance and sub-optimal use, there is urgent need to complement the required nutrients through all available sources. Organic materials, besides being a source of nutrients, will contribute to improve soil productivity and nutrient use efficiency of applied mineral fertilizers. A lot of data has been generated through research on different components of IPNM, but remain to be packaged for adoption by farmers. (*continued on p. 2*)

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*B.A.T.: Best Available Technology in fertilizer production
B.M.P.: Best Management Practices in fertilizer use.

Regional research network on fertilizer management for crop production on the acid-sulfate soils *(continued from p. 1)*

The effects of each one of phosphate rocks are compared to the effect of water-soluble fertilizer (TSP) and a control without P application. The rate of P application is 90 kg P₂O₅ per hectare per crop.

The most appropriate rice cultivar for the local conditions was selected for the experimentation.

The basic plot size was set large enough to allow later for split-plot treatments (with and without P) and measurement of the effects of residual and cumulative P applications.

Preliminary Laboratory Data:

The laboratory experiments on the kinetics of isotopic exchanges of soil P show considerable P fixation by soil. Kinetic studies performed one month after incubation of soil with various rock phosphates show the following:

* The soils tested from Thailand, Indonesia, and China, have a very high fixing capacity for P.

* The percentage of P remaining in the soil water solution after 1 minute of phosphate contact with soil (considered to be readily available to plants) varies from 1.5% to 5.4%.

* When some RP's are added to the soil (at the rate of 50 mg of P/kg of soil, corresponding to nearly 340 kg P₂O₅/ha), the fixing capacity decreased after 1 month of RP contact with soil. Small differences were observed in the magnitudes of the decrease in P fixing capacity as a result of the added RP.

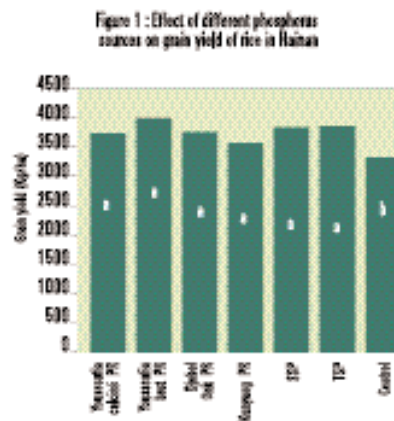
If we strictly extrapolate these data to the field experiments, we should assume entire first crop uptake and/or soil fixation of the P added (90 kg P₂O₅/ha). However, acid sulfate soils are heterogeneous at the field level. This implies a need to assess the P fixing capacity of the soil by splitting the experimental plots into two sub-plots, one receiving the same P fertilization as the first rice cropping

(90 kg P₂O₅/ha) while the second receives no P. This will enable to determine the residual effect, if any, of the P added in the first cultivation.

Preliminary Field Data:

The effect of PR application on rice in China and Malaysia are outlined below:

1. In China, at the Hainan site (fig.1), all phosphate treatments increased yield significantly for the first crop compared with the control without P. Similarly, at the Zhanjiang site (Guangdong), all



phosphate treatments increased the first crop yield significantly compared with the control treatment (fig.2).

Furthermore, it can be noticed that TSP brought about the highest yield

2. In Malaysia, results obtained for the 1st crop show only slight effect of the different P sources on the marketable yield of rice planted

on Sedu soil (Table 1). It is worth outlining the high rice yields obtained, which range from 4 to 6 tons grain per hectare, with yields at the actual sulfate soils (Sedu) higher than those on the potential sulfate soil (Jawa)- This might result in differentiating the P management on these two soil types. Data from the subsequent crop seasons might provide in-depth information in this respect.

In conclusion, the preliminary field data for the first rice crop indicate that in some cases (China for example), it is possible to have immediate effect of PR applications on the rice yield in acid-sulfate soils. In other cases (Malaysia, for example), it might be necessary to have accumulation of P applications before inducing an increase in rice yields. Furthermore, when data from all the participating countries will be pooled and analyzed, interesting information on different management options might be derived from the overall interpretation □

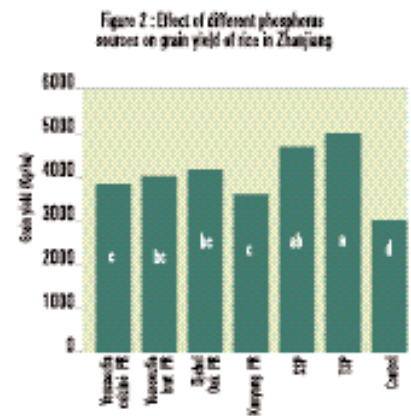


Table 1. Marketable yield of rice variety MR 84 (ton ha⁻¹) in soil treated with different phosphate sources at 90 kg P₂O₅/ha

Soil	Control	Christmas Island PR	Togo PR	Morocco PR	Jordan PR	TSP
Sedu	5.90	6.10	5.90	6.00	5.90	5.80
Jawa	4.40	4.70	4.75	4.15	5.25	3.92

Integrated plant nutrient management *(continued from p. 1)*

- Pakistani soils have become over time impoverished and limited in crop productivity. Fertilizer use has contributed considerably to crop yield improvement. Yet, fertilizer applications remain imbalanced, especially in respect of P and K where needed and micronutrients in some cases, resulting in low efficiency of the applied nutrients. It is, therefore, concluded that concerted efforts should be made to facilitate the promotion of balanced and adequate use of nutrients from mineral, organic and biological sources. Their use poses two-sided challenge: 1) education of farmer, and 2) a government fertilizer policy conducive to relatively favorable pricing and product availability and quality.

- Legumes are an important source of nitrogen and organic matter. It is estimated that about 20% economy in N use can be achieved through cultivation of leguminous crops. Adequate information is available on utilizing legumes in cropping systems and should be made accessible to farmer for adoption and suited to his specific farm conditions.

- Biofertilizers are newer on the scene and there is a range of them. The rhizobium inoculants are already established for legumes and should be as such promoted. Other microbial products presumed to improve crop productivity require a careful approach and need further evaluation in anticipation of a wider adoption. National standards for all

biological products need to be established and implemented to serve the interest of the farmers. Similar standards relating to quality control of mineral fertilizers should apply to biofertilizers.

- Long-term trials need to be strengthened and encouraged in different agro-ecological zones covering all-important soils and cropping systems in order to monitor the effects of major NPK nutrients alone and in combination with organic sources of nutrients. These trials will help in the long run clarify ambiguous aspects of nutrient depletion and buildup. Besides, they are useful in developing a balance sheet of nutrients and studying synergic effects of nutrients and ulti-

mately refining the fertilizer recommendations.

- Cropping systems need to be considered for formulating fertilizer recommendations that should account for both inorganic and organic sources of nutrients.
- NFDC, with all its expertise and capabilities, is the best-suited institution that can act as a driving force for IPNM-related activities. The Center should arrange for the organization of media coverages, regional seminars, and

training courses and should produce literature for IPNM adoption. The Government should provide necessary financial and technical support.

- A National Action Plan (NAP) on the promotion of IPNM needs to be developed for major crop production regions. It should make use of all relevant expertise and institutions in a collective effort to facilitate the transfer of available technology on IPNM. NFDC should take lead in this regard.

Based on the appropriate technology recognized in the NAP, pilot demonstration trials in different crop zones should be initially taken up to facilitate farmer acceptance. In addition, appropriate extension services should be devised for grass-root dissemination of IPNM approach to the farmers.

- With NFDC as the convener, a steering committee on IPNM representing all disciplines and related institutions should be constituted from both public and private sectors □

Guidelines for quality fertilizers under pressurized Irrigation Systems*

On most developing countries, high population growth rates, scarcity of water resources and shrinking per capita share of arable land render intensive farming patterns inevitable for meeting the increased demand for agricultural commodities. Irrigated farming offers an alternative option for intensive crop production. Under this option, fertilizer-water management has a greater impact on crop yield than any other single factor. With the spread of pressurized irrigation systems, the application of fertilizers to plants through irrigation water (i.e. fertigation) has become commonplace. At present, fertigation system represents a feasible and sound management method due to its higher water use efficiency and safer impact on the environment.

The agronomic benefits of fertigation are derived from the delivery of the right amount of plant nutrients at times to match crop physiological needs. On the environmental side, it is also possible to avoid excess fertilization and minimize the potential hazard of nutrient leaching or loss from the soil-water-plant system.

With so much to gain from fertigation, it becomes essential to use the right type and formulation of fertilizers that fit such system. Before injecting any fertilizer in the irrigation pipe, there must be precaution in the selection of fertilizer's raw material and adoption of standard properties, such as low corrosiveness to pipes and equipment, low salt index, high solubility, high purity, and favorable pH effect.

In April 1999, an IMPHOS Regional Workshop was held in Amman on Plant Nutrient Management under Pressurized Irrigation Systems in the Mediterranean Region with important support from the Jordan Phosphate Mines Company (JPMC) and the National Center of Agricultural Research and Technology Transfer (NCARTT). The Workshop called for:

* Proper plant nutrient management to promote and sustain productive and efficient cropping systems under pressurized irrigation.

* The use of quality fertilizers in fertigation systems, recognized as efficient water and fertilizer-saving techniques.

When farmers follow best agricultural practices and best available technology is adopted by fertilizer industry; then the



optimum agronomic, economic, and environmental conditions can be expected from the use of quality fertilizers.

Quality fertilizers and the user needs

Quality fertilizer could be described as the one that meets the timely agronomic needs of plants, that is technically and economically feasible and friendly to the environment. Evidently all these qualities are equally important and below are brief accounts of the main considerations in this regard.

■ Fertilizer Elemental Analysis and Formula

This refers to the content of the soluble forms of the three basic nutrients: N, P, and K - expressed as elements or in their oxide forms. The higher this analysis, the higher value the fertilizer is. Some countries put a condition that to import a fertilizer material, it should have at least 50% of one or a combination of the three elements. Of course there is a wide variety of chemical forms that differ in their solubility and availability to plants for each fertilizer, such as NO_3 , NH_3 , HNO_3 , NH_2 , ... for N, and H_2PO_4 , HPO_4 , and PO_4 for P, and so on. The fertilizer formulations are also difficult to assess and include soluble powders, granulated, coated, pellets, bricks, sticks/poles, liquid, suspension, ...etc. Each formulation has its properties, merits and usage for certain crops and special user needs.

■ Raw Materials

Mineral fertilizers are generally produced from a small number of different naturally- occurring raw materials and other intermediate products. Natural gas, other hydrocarbons, rock phosphate and potassium salts are the main raw materials. The discussion below will focus on guidelines for selecting appropriate raw material, and at the factory level, for producing the finished product of fertilizer that is used for fertigation.

↪ Soluble Powder Fertilizers

Good quality soluble powder fertilizers are produced from completely soluble crystalline raw materials that are crystal clear and 100% soluble in water, with no dissolved particles to clog irrigation lines or equipment. Once a fertilizer is dissolved in water, it should not precipitate at constant temperature and should remain in solution. Soluble powder fertilizer should be formulated from blending a uniform soluble salt mixture that is not corrosive to irrigation lines or equipment, has low salt index, highly soluble and highly pure. Soluble powder fertilizers may be used for fertigation or foliar application.

↪ N-Fertilizers

Urea is one of the most suitable nitrogen sources as soluble powder fertilizer as well as foliar liquid fertilizer. It has low salt

index and high solubility in comparison to other nitrogen sources. Urea should be low in biuret content (less than 0.2%) so that it will not result in biuret hazard to plants even if applied as a foliar fertilizer. Besides urea, other N sources such as ammonium nitrate, ammonium sulfate, ammonium phosphate and urea phosphate are excellent supplemental nitrogen carriers with minimal side effects.

➔ P - Fertilizers

Most dry phosphorus fertilizers produced for general farm applications cannot be used for the production of soluble powder fertilizers because they contain high percentage of insoluble material. Monoammonium phosphate (MAP 12-61-0), diammonium phosphate (DAP 21-53-0), monobasic potassium phosphate (MKP 0-52-34), urea phosphate (17-44-0) are very common sources for P in the production of soluble fertilizers.

Farmers using hard water may experience some precipitation problems with neutral fertilizers. Farmers who inject P through drip and microirrigation systems, should use acidic forms of P fertilizers rather than neutral forms. Caution should be exercised because low pH values (below 5) may induce corrosion of metal hardware and increase toxicity of certain micronutrients. Urea phosphate materials are quite excellent fertilizers. They have a low enough pH to prevent Ca and Mg precipitation. In addition, they are an excellent source of N. They can also retard P precipitation in highly calcareous soils and improve P availability in the soil.

➔ K - Fertilizers

All potassium fertilizers are water-soluble. Potassium sulfate, potassium nitrate and monobasic potassium phosphate are potassium raw materials used for making soluble powder fertilizers. While potassium chloride has high solubility as a soluble powder fertilizer, it is not a desirable source of K for vegetables and crops that are sensitive to high levels of chloride.

■ Fertilizer Compatibility

Compatibility problems may occur when liquid or soluble powder fertilizers are combined. When preparing fertilizer solutions from various materials, the following should be considered: the safety involved in making the solution, effect of solutions on each other, type of irrigation system and its susceptibility to plugging or other problems.

It is always advisable to run a "jar test" to check fertilizer compatibility before preparing large batch of liquid fertilizer or injecting the fertilizer solution in the irrigation system. This test involves dissolving some of the fertilizers into a jar of irrigation water, and watching for any precipitation or milkiness which may occur within one hour. If cloudiness does occur, there is a chance that injection of the fertilizer/chemical will cause emitter plugging. If more than one fertilizer is to be injected simultaneously into the irrigation system, then the two are to be mixed in a jar and used at the approximate dilution rate that would be expected when the products are injected into the irrigation system.

Some Precautionary Measures for Mixing

The basic mixing rules are as follows:

- Always fill the mixing container with 50-75% of the required water to be used in the mix.
- Always add the liquid fertilizer materials to the water in the mixing container before adding dry soluble fertilizers. The additional fluid will provide some heat in case the dry fertilizers have the characteristic of making solutions cold.
- Always add the dry ingredients slowly with circulation /agitation to prevent the formation of large, insoluble or slowly soluble lumps.
- Always add acid to water-not water to acid.
- When chlorinating water with chlorine gas, always add chlorine to water, not vice versa.
- Never mix an acid or acidified fertilizer with chlorine, neither in its gas form or liquid form. Never store acids and chlorine together in the same room.
- Do not attempt to mix either anhydrous ammonia or aqua ammonia directly with any kind of acid. The reaction is violent and immediate.
- Do not mix concentrated fertilizer solutions directly with other concentrated fertilizer solutions.
- Do not mix a compound-containing sulfate with another compound containing calcium. The result will be a mixture of insoluble gypsum. For example, injecting both calcium nitrate and ammonium sulfate fertilizers into the same irrigation water will cause the formation of calcium sulfate (gypsum), which has a very low solubility. Although the calcium nitrate is very soluble and the ammonium sulfate has good solubility, they create problems when mixed together in the same container or when poured together from separate mixing tanks. Gypsum crystals will form and can clog drip emitters or filters.
- Always check with the chemical supplier for information about insolubility and incompatibility.
- Be extremely cautious about mixing urea sulfuric fertilizers with most other compounds. Urea sulfuric is incompatible with many compounds.
- Since fertilizer solutions are applied in very small dosages, and if injected at separated locations in the irrigation line, many incompatibility problems tend to disappear. The jar test is essential when it comes to deciding if solutions can be simultaneously injected into the irrigation system.
- Do not mix phosphorus-containing fertilizer with another fertilizer containing calcium without first performing the jar test.
- Extremely hard water (containing relatively large amounts of calcium and magnesium) will combine with phosphate, neutral polyphosphate or sulfate compounds to form insoluble substances.
- A good rule of thumb: "when in doubt leave it out."

CONCLUSIONS AND RECOMMENDATIONS

- Pressurized irrigation - usually equipped with fertigation systems-are gaining more acceptances, and this should be promoted as an efficient system for water-fertilizer use.
- Fertilizers of special properties, types, formulations and grades are required for meeting the changing demand of various crops and needs of users.
- For achieving the main goal of using fertilizer in sustainable agriculture, the best available technology is required by the fertilizer producers, as well as the adoption by farmers of best agricultural practices.
- A set of guidelines is called for to ensure the proper formulation and usage of quality fertilizers in order to grasp the technical, environmental, agronomic and economic benefits of fertilizers for sustaining soil productivity.
- Cooperation and effective linkages are needed to be established between all stakeholders, including farming community, research institutions, agricultural extension and training, international / regional institutes and organizations, as well as the producing sector for furthering the goals of efficient and environ-

mentally-friendly use of mineral fertilizers.

- International Organizations/Centers and the fertilizer producing sector are urged to assume an effective role in providing material support to governmental research/extension systems in order to enable them to outreach farmers and deliver the adequate knowledge on fertilizer use, for the benefit of all parties □

* Excerpt from a paper presented by Dr G. Hamdallah at the IMPHOS Regional Workshop on "Plant Nutrient Management under Pressurized Irrigation Systems in the Mediterranean Region" held in Amman, Jordan, April 25-27, 1999



Changes in Cadmium Phytoavailability in Soil

Since human disease from soil Cd was first announced in 1969, research in many areas has characterized factors which affect phytoavailability of soil Cd. Research has shown that soil properties can play an important role in Cd uptake and accumulation in grains. Furthermore, cultivation of some crops such as rice allows movement of Cd from soil to grain without the accompanying Zn that is known to inhibit uptake of Cd by plants. But such high rice transfer of soil cadmium to grain is really unique.

The long-term changes in total and phytoavailable Cd in soil has been examined in a recent study conducted by three researchers from Australia and published in the journal of "Environmental Science and Technology" in 1998. The aim of this study was to determine whether the phytoavailability of Cd could decline with time due to fixation of Cd in the soil.

Clay loam soil from experimental field plots at Armidale NSW was sampled. The plots have received different application rates of single superphosphate (SSP) since 1948, and hence soil from the plots was expected to contain different concentrations of Cd. Specifically, plots used in the current experiment had annual applications equivalent to 62.5, 125, and 250 Kg of SSP/ha. In 1975, the plots were split such that fertilizer applications were terminated on one half of each plot until the present time [rundown (R) plots] while the same application rates of fertilizers were maintained on the other half of each plot until the present time [continuous (C) plots]. Pasture species are established on the plots that have also been individually grazed by sheep since 1952.

The air-dried soil was sieved and thoroughly mixed and then placed into plastic pots and the moisture content increased to 50% of the water holding capacity. Replicates of the R and C soils were potted.

Seeds of wheat were sown in the soil and plants were grown in a controlled environment growth chamber. The moisture content was maintained and nutrients were provided in replenishing water lost through transpiration. The plant shoots were harvested and analyzed.

► Main Findings

Soils: Application of superphosphate at different rates appeared to have no effect on soil pH with the mean value for all the plots found to be around 5.95. Accumulation of Cd in the soil was highly correlated to the application rate of SSP. Neither plant composition differences nor the fact that plots were grazed by sheep appear to have had any effect on the total

Influence of the Application Rate of Single Super Phosphate on Cd Content in Soils and Yields of Wheat Shoots

Plot	Total Soil Cd (mg/kg)	Increase in soil Cd (mg/kg/yr)	Shoot dry weight (g)
Nil SSP	0.026	Nil	
62.5 R	0.070	0.0016	0.061
62.5 C	0.115	0.0019	0.084
125 R	0.147	0.0045	0.081
125 C	0.198	0.0037	0.149
250 R	0.195	0.0063	0.097
250 C	0.339	0.0067	0.179

content of Cd in individual plots. Moreover, the concentration of Cd in the SSP applied to these plots did not change significantly during the last 20 years of application. Similarly, No evidence was found to indicate offsite movement of Cd, either through horizontal transfer or via leaching through the profile for at least the last 20 years.

Plant: Plant growth was different between soils, with increased yields noted in soils from plots that had received the highest rates of SSP application (see table above). Increases in soil Cd led to an increase in the Cd content of wheat that was grown in the soil. However, using a radioisotopic dilution technique, a significant proportion of the added Cd was found to exist in a non-bioavailable pool in the soil.

The positive trend between concentration of Cd in the soil and the Cd content of plants contrasts with results of several authors, who concluded that there was no evidence to suggest that Cd concentrations in herbage increased due to long-term applications of phosphate fertilizers. In their studies, addition of fertilizers not only led to an increase in cadmium concentration in the soil but also to a significant increase in plant yield. Hence, a possibly large confounding factor, was 'dilution of Cd' in herbage due to the higher yields.

In the present experiment, available Cd could be determined despite the yield differences obtained. In soil from the R plots, approximately 60% of the Cd were in a plant available form. Cadmium was generally more phytoavailable in C plot soils with a mean of 72% of the total Cd in a plant available form.

The table above shows that the total cadmium concentration of soils from the R and C series ranged from 0.05 to 0.20 and from 0.10 to 0.35 mg of Cd per kg of soil, respectively. A

linear correlation was found between soil Cd and the rate of application of SSP. The linearity of the data provides a strong indication that the concentration of Cd in the SSP applied to these plots did not change significantly during the last 20 years of application.

This result therefore provides evidence (i) that pools of non-phytoavailable Cd can exist in the soil, and (ii) that at low concentrations of Cd in the soil, the amount of Cd fixed is proportional to the concentration of soil Cd.

For a given concentration of Cd in the soil, Cd was significantly less phytoavailable in plots that had received their last input of Cd in 1975(R plots) as compared to those still subject to Cd inputs(C plots). This segregation between R and C plots further implies that there is a time-dependent component associated with declines in Cd phytoavailability. From these data, it was possible to calculate an approximate annual rate of Cd fixation in the soil. Using a derived model, it was estimated that Cd was being fixed in this soil at a rate of 1-1.5% of the total added Cd per year.

► Conclusion:

The fact that Cd can exist in non-phytoavailable pools in soils adds further impetus to arguments that the totals-based approach, which is widely in use for delimiting maximum allowable concentrations of metals in soil, is inappropriate. Moreover, evidence that Cd and other metals can be fixed in soils suggests that to alleviate potential health risks of contaminated soils, it may be unnecessary to achieve huge reduction in the total concentration of Cd in the soil. Risks to health may be mitigated even without significant reduction in the total soil content of metal ☐

Fertilizer Requirements in 2015 and 2030

There appears to be some consensus in the research community about the likely future path of global agricultural production. Growing world population and per capita incomes will likely require more intensive agricultural crop production. Higher yields will, in turn, increase the demand for agricultural inputs especially mineral fertilizers. Furthermore, future agricultural cropping patterns will reflect shifts in diets (e.g. greater meat consumption). Greater opportunities for agricultural trade may also lead to regional shifts in world crop production. At the same time, there will likely be economic and environmental incentives to improve the efficiency of fertilizer use over current levels in all countries, but especially in the developed countries.

What are the cumulative effects that the consensus may have on future fertilizer use? This is the overall goal of this paper given at the "IFA Agricultural Conference on Managing Plant Nutrition", held in Barcelona in June-July 1999*.

The specific Objective of this paper is to explore the bounds on the amount of fertilizer needed to support the FAO projections of agricultural commodity production for 2015 and 2030. The authors make three alternative assumptions to relate yield or production projections and available data on fertilizer application rates to estimate total fertilizer or nitrogen fertilizer use:

- A base case where total fertilizer use grows at the same rate as crop production to 2015 and 2030.
- A fertilizer growth case where total fertilizer efficiency is expected to improve for all crops and countries; and
- A case where nitrogen fertilizer use in the future is based on the early 1990's relationship between yield and nitrogen application rates for the major cereal crops in the major producing countries. Wheat, rice, and maize were chosen as the major crops for more detailed analysis because they account for over half of the nitrogen fertilizer consumed on a global basis and because nitrogen can have adverse effect on the environment.

Cereal Demand and Supply: At the world level, the most notable trend is the steady decline in the annual population growth rate from 1.8 percent for 1980-91 to 1.5 percent projected for the period 1991-2010, with further declines expected into the middle of this century. With declining population growth, aggregate growth in demand for cereals is likely to slow significantly.

While population growth tends to drive increases in de-

Actual and Projected Annual Growth Rates for Population and Cereal Consumption and Production for Selected Years

Country categories	Years	Population	Cereal consumption	Cereal production
Developed countries	1970-80	0.8	1.6	2.4
	1980-91	0.7	0.7	0.6
	1991-2010	0.6	0.7	1.1
Developing countries	1970-80	2.0	3.6	3.1
	1980-91	2.1	2.8	2.7
	1991-2010	1.8	2.1	1.9
World	1970-80	1.7	2.5	2.7
	1980-91	1.8	1.8	1.6
	1991-2010	1.5	1.6	1.6

mand for agricultural commodities, growth in supply is typically attributed to yield and cropland area changes. Yield increases will likely remain the engine for output growth.

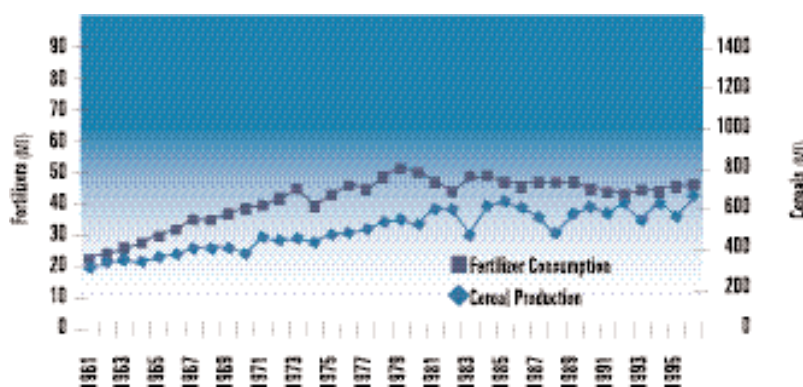
Cereal production growth in developing countries will likely outpace that of the developed countries during the first part of this century.

Fertilizer Demand: The role of mineral fertilizer in support of growing demand for agricultural commodities is

well-established (figure 1). Over the last 30 years, there has been a positive correlation between cereal production and fertilizer use in developing countries, which currently use the bulk of mineral fertilizers and exhibit the largest rates of growth relative to developed countries.

Several recent studies have suggested that the expected continual yield (and production) increases during the next 30 years will likely require increases in the use of fertilizers.

Fertilizer consumption and cereal production in developed countries excluding Eastern Europe and FSU



Baseline Scenario

Crop	Crop Production (million t)			Average (%) ann. Growth		Fertilizer Use (million t)		
	1995-97	2015	2030	2015	2030	1995-97	2015	2030
Wheat	509.6	689.8	805.4	1.5	1.3	24.7	33.5	38.9
Rice	534.5	690.4	755.5	1.3	1.0	21.3	27.3	29.3
Maize	516.2	720.8	872.9	1.7	1.5	19.3	26.7	31.6
Barley	99.3	130.0	151.3	1.4	1.2	4.1	5.8	6.9
Other cereals	115.6	141.2	164.9	1.0	1.0	5.0	5.9	6.6
Cotton	45.9	69.5	95.8	2.1	2.1	4.6	6.9	9.3
Vegetables	390.4	480.6	540.1	1.1	0.9	4.8	5.6	6.2
Sugar cane	969.5	2077.5	2517.1	3.9	2.8	3.6	7.7	8.2
Soybean	122.5	154.8	195.2	1.2	1.3	3.8	5.0	6.0
Other crops	1020.1	1322.3	152.9	1.2	1.2	36.4	42.3	47.0

*S.Daberkov, USDA, K.F. Isherwood, IFA Paris, J.Poullisse, FAO Rome and H. Vroomen, TFI 1999. "Fertilizer Requirements in 2015 and 2030", IFA Agricultural Conference of Managing Plant Nutrition, 29 June-2 July 1999.

Deriving Fertilizer Use Estimates from Crop Production Projections:

To derive estimates of mineral fertilizer use based on FAO crop production projections, three techniques were used, each making different assumptions about nutrient use efficiency over time.

1 Baseline Scenario: This is calculated from applying the anticipated crop production growth rate to the fertilizer quantity consumed in the 1995-97 base year (i.e. a 10 percent increase in maize production growth leads to a 10 percent increase in fertilizer use in maize production). Essentially, the output/input relationship between fertilizer use and crop production present in the 1995-97 base year is assumed to remain constant throughout 2015 and 2030.

According to this scenario, global fertilizer use is expected to increase from 133.9 million tons nutrients in 1995-97 to 174.7 and 199.2 millions tons in 2015 and 2030 respectively, i.e. at an average annual growth rate of 1.3% and 1.1% respectively, the same as the world crop production average annual growth rate. The table below shows actual production of major crops and fertilizer use for 1995-97 base year and projected crop production and fertilizer use in 2015 and 2030.

2 Increased Nutrient Efficiency Scenario: There is evidence that increases in food production can be obtained with less than proportional increases in fertilizer use. Farmers achieve such an increased nutrient use efficiency through adoption of improved and more precise management practices.

Fertilizer productivity, as measured by kg yield/kg fertilizer, shows considerable variation across countries, which likely reflects differing resource bases. Given this variability, the scope for higher levels of fertilizer productivity is substantial. In this scenario, nutrient use efficiency was allowed to in-

Estimates of nitrogen fertilizer use (million t) on cereals for two scenarios

Crop	Nitrogen Scenario			Baseline Scenario	
	1995-97	2015	2030	2015	2030
Wheat	16.3	21.1	25.4	22.2	26.3
Rice	15.0	21.3	23.6	19.3	21.0
Maize	12.1	16.8	20.4	16.8	20.5
Crop subtotal	43.3	59.2	69.4	58.4	67.7
All crops	77.8	106.3	124.5	100.4	117.7

crease for all countries and crops from their 1995-97 base. Fertilizer growth rates are calculated to fall to about 0.7 percent annually over the next 35 years. Nevertheless, total nutrient use rises from 134 million t/year to 166 million t/year. Sugar cane and cotton production remain the largest growth markets, while other cereals and vegetables are expected to be stagnant or declining markets. The major cereals appear to be bidding land, and fertilizer, away from the minor cereal crops. Under this scenario, Latin America joins Eastern Europe and sub-Saharan Africa as the fastest growth markets through 2030. As under baseline scenario, the regions with primary developed countries tend to be the fertilizer markets with the slowest growth.

3 Nitrogen Use on Cereals: Because of the robust relationship between application rates of nitrogen and yields for the three major cereal crops, the authors examined nitrogen use given the assumption that the major cereal producing countries will adopt similar fertilizer use technology as yields increase in the future. This scenario did not result in significantly different estimates compared to the baseline scenario. The nitrogen fertilizer growth only increased from 1.5 percent annually to 1.57 between 1995-97 and 2015, and from 1.28 to 1.35 between 1995-97 and 2030.

Assumptions, Conclusions and Implications

The baseline scenario presumes that an increase in the production of a given crop is accompanied by a proportional increase in fertilizer nutrient use. It ignores economic and other factors and future improvements in nutrient use efficiencies and, thus, is likely to present an overestimate of future nutrient use in numerous countries whose improvement in N-P205-k20 balances are far from optimal. As they move toward more balanced rates of application, considerably higher nutrient use efficiencies may be achieved. The increased nutrient use efficiency scenario attempts to address some of the limitations of the base case scenario. The model for the final scenario was a fertilizer requirement function.

In these analyses, the authors attempted to place bounds on the amount of fertilizer needed to support FAO's yield and area projections to 2015 and 2030. Their estimates are similar to those in other studies, which indicate a slowing in the growth of fertilizer use. Satisfying demand for food in the next century will clearly require further increases in fertilizers but at lower growth rates compared to the last 40 years.

Wheat, rice and maize will continue to dominate fertilizer markets with the expectations that fertilizer use on maize will exceed rice by 2030—a consequence of greater demand for meat in developing countries □

Increased Nutrient Efficiency Scenario

Crop	Production Growth (%)		Fertilizer use (M t)			Growth (%)	
	2015	2030	1995-97	2015	2030	2015	2030
Wheat	1.5	1.3	24.7	28.8	31.6	0.8	0.7
Rice	1.3	1.0	21.3	23.0	23.8	0.4	0.3
Maize	1.7	1.5	19.3	22.0	24.6	0.7	0.7
Barley	1.4	1.2	4.1	4.6	4.9	0.5	0.5
Other cereals	1.0	1.0	5.0	4.7	4.9	0.3	0.0
Cotton	2.1	2.1	4.6	5.8	7.0	1.1	1.2
Vegetables	1.1	0.9	4.8	4.2	4.1	0.7	0.5
Sugar cane	3.9	2.8	3.6	5.9	6.9	2.5	1.9
Soybean	1.2	1.3	3.8	4.1	4.7	0.3	0.6
Other crops	1.2	1.2	36.4	41.1	45.5	0.6	0.6

Agriculture technology to cultivate peace*

Agriculture and the rural sector are at the center of the development failure of states, hence the socio-economic and political crises that lead to violent conflict. Agriculture is especially important in poor developing countries as it supplies the bulk of livelihood for people.

Building peace and prosperity will require greater attention to the role of agriculture in creating livelihood, resurrecting development, alleviating poverty, and breaking the vicious cycle of violent conflict and scarcity.

Western Europe has evolved into an elaborate security community despite its long history of warfare, including two "world wars" in the last century. The rapid recovery of East and Southeast Asia from postwar destitution to economic prominence demonstrates that building prosperity and peace is possible in other areas as well. Developing agriculture and satisfying the need for food were crucial elements in this process.

Improving conditions facing the agriculture sector on a global scale is vital for peace and prosperity, and for

achieving sustainable development. Addressing the problems facing agriculture and the rural communities should be foremost within strategies that seek to bring about prosperity and peace. Closely linked to such issues is the larger political-economy setting where states should minimize taxing agriculture and rural society and eliminate the distortions that harm overall economic performance and agriculture growth. Part of the process of eliminating distortions would be for politicians in both the North and the South to come to equitable terms about access to markets, control of capital, and other relevant financial and trading issues.

Provision of land for small farmers is crucial step in the campaign to improve productivity. However, systematic analysis of settlements of new land in West Africa show that the productivity and incomes of these farmers improved only marginally in the absence of good technologies and inputs. The development of high-yield crops and better methods of farming is crucial for increasing production without negative

environmental consequences.

Research has an important role to play in lowering the costs of production while sustainably increasing output in Asia, Africa and Latin America.

Rural societies all over the world stand to gain from technologies and from learning how to improve the quality of food and preserve the environment. The elimination of scarcity will ultimately promote peace and development and improve the quality of rural life. Peace and prosperity in the developing world will also have a positive impact on the well-being of the industrialized societies by helping to create and sustain jobs and stemming problems arising from mass immigration and "refugeism". □

*Article excerpted from PRIO report 1/99; Indra de Soysa and Nils Petter Gleditsch.

Yield Benefits associated with balancing nutrients applied on some crops in Asia

In many developing countries, in Asia in particular, fertilizer use is tilted in favor of nitrogen for reasons having to do with cost. The relatively low cost per unit nutrient of fertilizer nitrogen and its widespread availability in countries such as China, India and Pakistan, for example, make

for N applications 3 to 4 times higher than P applications. On rice this unbalanced use of plant nutrients results in lodging, greater weed competition and pest attacks. Paddy yield losses range from about 20%, up to 50% under some conditions. Several on-farm and on-station trials have

demonstrated the need for balancing N and P fertilizers and their effect on crop yields. Data shown in the table from trials conducted in India highlight the significance of balanced fertilization on cultivated crop.

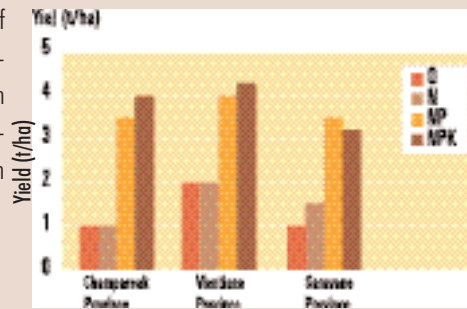
Crops	N application (kg/ha)	yield increase (kg/ha) with N over control	N-P:O: application (kg/ha)	yield increase (kg/ha) with NP over control	Additional yield increase (kg/ha) over N due to P
Rainfed rice	120	1186	120-60	1791	605(51)
Irrigated rice	120	800	120-60	1510	710 (89)
Irrigated wheat	120	915	120-60	1473	558 (61)
Rainfed sorghum	90	342	90-60	561	219 (64)
Rainfed maize	90	1046	90-60	1316	271 (26)
Rainfed millet	90	270	90-60	550	280 (103)
Pigeonpea	20	291	20-40	630	339 (116)

Source : derived from Randhawa N.S and tandon H.L.S, 1992

() : Increase in %

Rice yield responses in on farm NPK omission studies in Lao PDR*

The above yield data indicate little or no responses of lowland rice to N and K, but high responses to phosphorus fertilizer at application rates of 30 kg/ha P₂O₅ when N is applied at 60 kg/ha N. This result is clearly illustrated by the following crop response curve to P application in the Saravane District. □



*Source: derived from Phoudalay Lathvilayvong et Al, 1996. Soil limitations for rainfed lowland rice in the Lao PDR. Paper given at the International Workshop on Breeding Strategies for Rainfed Lowland Rice in Drought Prone Environments - Ubon Ratchathan, Thailand, 5-8 November 1996.

PUBLICATION

Plant Nutrition Management for Sustainable Agricultural Growth.

Proceedings of the symposium on «Plant Nutrition Management for Sustainable Agricultural Growth» organized from 8 to 10 December 1997 in Islamabad by National Fertilizer Development Centre (NFDC), Islamabad with support of Food and Agriculture Organization of the United Nations (FAO) the World Phosphate Institute (IMPHOS) and in collaboration with Ministry of Food, Agriculture and Livestock (MINFAL) and Fertilizer Industry. The symposium was attended by more than 100 participants from all over the country and abroad. The delegates from IPI, IFA, FAO, IFFCO and IMPHOS also participated to this symposium.

The symposium proceedings include eight oral technical sessions in addition to poster presentations. A panel discussion on the subject «Sustainability of Agriculture in Relation to Plant Nutrition Management and Fertilizer Use» is also included

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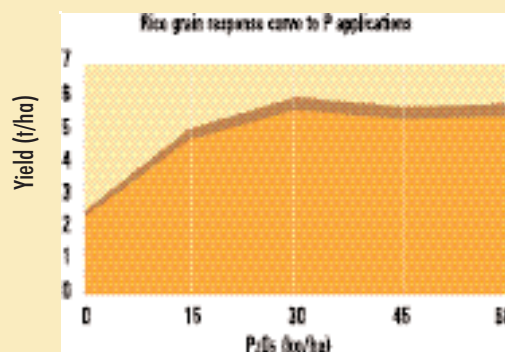
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Rice grain yield responses to phosphorus application

Plant nutrient management studies highlighted the significance of low soil- P status as crop yield limiting factor, and the P requirement of rice crop. The critical role of P fertilization in improving rice yield is clearly demonstrated in these Lao PDR trials □



COMING EVENTS*

1-4 October 2000 :

IFA Technical Conference

New Orleans, USA (Open to IFA members only)

Email : ifa@fertilizer.org

Web : www.fertilizer.org

23-24 October 2000 :

Regional IPI workshop on Potassium and Phosphorus : Fertilisation effect on soil and crops

Dept. of International Integration, Lithuanian

Institute of Agriculture, 5051 Dotnuva -

Akademija, Kedainiai distr., Lithuania

Fax : + 370 57 60996

Email : ausra@lzi.lt

29 October - 1 November 2000

San Francisco - USA

Sulphur 2000

Tania Atkinson, Conference Administrator British Sulphur Publishing, 31 Mounth Pleasant, London WC1X 0AD, UK

Tel.: +44 (0) 207 903 2444

Fax: +44 (0) 207 837 4339

E-mail: tatkinso@cruint.tcom.co.uk

6-17 November 2000 :

IFDC International fertilizer Marketing Training

Programme - Thailand

International Fertilizer Development Center

Fax : + 1 256 381 7408

Email : hrd@ifdc.org

Web : www.ifdc.org

4-7 December 2000 :

IFA Regional Conference for Asia and the Pacific Yokohama, Japan (Open to IFA members only)

Email : ifa@fertilizer.org

28 July - 3 August 2001 :

14th International Plant Nutrition Colloquium

Honnover, Germany

Fax : + 49 511 762 3611

Email : ipnc@mbox.uni-honnover.de

3 - 9 August 2001

12th CIEC World Fertilizer Congress

Beijing, China. International Scientific Centre of Fertilizers (CIEC)

Contact Prof. Chen, Institute of Applied Ecology,
Shenyang, China

Fax : + 86 24 238 43313

Email : CIEC2001@pb.fal.de

* If you know of any other conferences or events related to plant nutrition /fertilizer use, please send them to us.

ABOUT IMPHOS

IMPHOS is a non-profit making Institute founded in 1973 by the world's principal producers of phosphate rock. Its primary mandate is to collect and disseminate scientific data to support the rational use of phosphates to both increase and sustain agricultural production to meet the food requirements of human-kind worldwide.

Among its objectives it seeks to promote, in both developed and developing countries, the efficient use of phosphates, according to the principles of integrated

plant nutrient management. It also seeks to improve farming techniques for productive and sustainable crop production, whilst minimizing environmental risks. Technical research includes the synthesis of phosphorus compounds and processing technologies.

In phosphorus deficient soils such as in Africa and Asia, IMPHOS is conducting several projects to demonstrate the need to supply phosphate to increase and sustain the food production. In phosphorus enriched soils, such as in Europe, the focus is made on

using phosphorus efficiently to both maintain productivity and minimize environmental risk.

To optimize the use of published research on phosphates, IMPHOS makes its expertise available, not only to member companies but also to research organizations, consumers and appropriate agencies. It also periodically organizes international conferences and regional seminars.

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Groupe Office Chérifien des Phosphates (OCP)

Angle route d'El Jadida et bd. La Grande Ceinture
CASABLANCA, Morocco
Tel : 212 2 23 00 25/23 10 25/23 01 25/23 30 25
Fax : 212 2 23 06 35

Web site : <http://www.ocpgroup.com>

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Web site : <http://www.jpmmc-jordan.com>

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