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IMPHOS TODAY

On-Farm Demonstration Trials to Promote Balanced and Efficient Use of Fertilizers in India

An IMPHOS extension project (2001 to 2004) was initiated in India to promote balanced and efficient use of fertilizers through on-farm demonstrations.

Currently, along with IFFCO, seven State Agricultural Universities (SAUs) are involved in this project, namely Punjab Agricultural University, Ludhiana; Birsa Agricultural University, Ranchi; Orissa University of Agriculture and Technology, Bhubaneswar; C.S. Azad University of Agriculture and Technology, Kanpur; Himachal Pradesh Krishi Vishva Vidyalaya, Palampur; Tamil Nadu Agricultural University, Coimbatore and Kerala Agricultural University, Vellanikkara. The field trials conducted under the project are the following:

- Efficiency of water-soluble P application methods in neutral soils;
- P requirements of crops grown on low-P soils;
- P requirements of crops grown on medium to high-P soils;
- Efficiency of rock phosphate (RP) application methods in acid soils;
- P requirements of high P loving crops;
- On-farm fertilizer management trials in low consumption area.

The project consists essentially of multi-location, single-replicated, on-farm trials. Different cropping systems are used representing various agro-climatic regions in the country. The central idea of the project is to disseminate to farmers in general the current knowledge on efficient use of fertilizer P in a balanced nutrition approach.

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BAT: Best Available Technology in fertilizer production
BMP: Best Management Practices in fertilizer use

Considering past and present activities of IMPHOS in India, it decided in consultation with the Fertilizer Association of India (FAI), to launch an Award to further its position and role in this widespread country. **The IMPHOS-FAI Award on Role of Phosphorus in improving the Yield and Quality of Crops**, was announced through FAI "Fertiliser News" Journal during the annual FAI meeting in December 2001.

All scientists/experts working in India were eligible to run for the Award. Their assessment was based on their published work during the previous 10 years preceding the year of the announcement of award. The winner of the first IMPHOS/FAI award was acknowledged at the Annual FAI Seminar held in New Delhi in December 2002. The Honorable Minister for Chemicals and Fertilizers (Government of India) bestowed second award upon **Dr Subba Rao** during the FAI Annual seminar on December 4, 2003. Dr. Rao and his associates from **BHOPAL** made significant contribution towards phosphorus management in Vertisols for sustainable crop yields. Their findings when adopted by farmers in India have helped them to improve crop yield and quality.

Table 1. Yield increase (%) with fertilizer addition in IMPHOS-IFFCO field demonstrations

State	Crop	Yield increase (%)		
		50%RD*over FP**	100%RD over FP	100%RD over 50% RD
Tamil Nadu	Black gram	26.4	50.9	19.4
	Chillies	58.3	75.0	10.5
	Groundnut	28.1	35.9	6.1
	Rice	-15.1	41.3	66.4
	Tomato	31.4	61.3	22.8
Madhya Pradesh	Chick Pea	50.1	94.2	29.4
	Wheat	18.8	48.8	25.3
Punjab	Cotton	1.9	10.0	7.9
	Rice	-6.8	6.3	14.0
	Wheat	-10.2	15.3	28.4
Uttar Pradesh	Groundnut	21.8	80.0	48.0
	Pearl Millet	13.6	29.5	14.0
	Rice	13.8	51.2	32.9
	Wheat	6.7	43.6	34.5
Himachal Pradesh	Maize	20.3	74.2	44.8
	Rice	6.8	35.0	26.4
	Wheat	11.1	34.8	21.4
Jharkhand	Rice	4.0	77.3	70.5
	Wheat	12.4	60.4	42.6
Bihar	Rice	-2.3	33.3	36.5
	Wheat	6.6	48.8	39.6
Chatisgarh	Wheat	1.4	44.8	42.9

**RD = State Recommended Dose, **FP = Farmer's Practice*

The project joint undertakings

the following activities have been undertaken jointly to disseminate widely the results from this extension project:

- A national-level meeting to launch on-farm trials on efficient use of phosphorus in balanced nutrition of crops in India was organized on July 3-4, 2000 at the IFFCO Fertilizer Marketing Development Institute, Gurgaon. The plan of work for this extension project was finalized and the involved institutes, including SAUs, were identified.

- A Group Discussion on crop responses to applied phosphorus in India was organized in December 2001 at IFFCO-Fertilizer Marketing Development Institute, Gurgaon. The topics discussed were the following: (1) Phosphorus-an essential nutrient for sustainable crop production; (2) crop responses to applied phosphorus-lessons from long-term fertilizer experiments; (3) crop responses to applied phosphorus in eastern India; (4) crop responses to applied phosphorus in western India; (5) crop responses to applied fertilizer phosphorus-lessons from all-India coordinated research project; (6) responses of pulses to applied phosphorus in different agro- climatic regions of India; (7) crop responses to applied phosphorus in rain-fed areas; (8) promotion of phosphorus use for increasing crop production.

On-farm Demonstrations

A 3-year programme on field demonstrations of balanced use of fertilizer nutrients in low fertilizer consumption areas was initiated in 9 States, namely Punjab, Himachal Pradesh, Bihar, Jharkhand, Madhya Pradesh, Chatisgarh, Uttar Pradesh, Tamil Nadu and Orissa, for 6 seasons starting from Rabi 2000-01. Demonstrations were laid out in those districts where fertilizer consumption is less than the State average. Each demonstration consists of 3 plots on the same site and based on the same cropping system: (1) Farmer practice; (2) 50% of the State recommended dose; (3) 100% of the State recommended dose. The recommended package of cultural practices are followed. Initially one composite soil sample was collected from each plot after the final harvest to evaluate changes in soil fertility status.

Some salient results are presented in table 1.

- Application of 100% of the State recommended doses of fertilizers produced the highest yield for all crops compared to that obtained using farmer practice or 50% of the recommended doses. Rice yield, for example, increased by 14% in Punjab to as high as 71% in Jharkhand, compared to yield obtained at the 50% of recommended doses. Wheat yield increased by 21% in Himachal Pradesh to 43% in Jharkhand. The rice yield increases over yield obtained using farmer practice ranged from 6% in Punjab to 77% in Jharkhand, while wheat yield increased by 15% in Punjab to 60% in Jharkand over farmers' practice.

- Farmers' practice was satisfactory for growing rice in Tamil Nadu and wheat and rice in Punjab, compared to practices using 50% of of the State recommended doses of fertilizers. This is probably due to farmers tendency in these states to apply relatively high level of nutrients.

Based on these demonstrations, farmers are advised to apply recommended doses of fertilizers in crop to obtain high yields. Recommended doses ensure balanced use of fertilizers.

Farmers meetings and field days

Farmers meetings and field days involved local farmers and those from neighbouring villages, district officials from different departments and representatives from the fertilizers industry. The total number of farmers who benefited from these meetings were 2,706 in Uttar Pradesh, 1,738 in Punjab, 669 in Bihar, 463 in Himachal Pradesh, 75 in Madhaya Pradesh and 45 in Chatisgarh. The meetings were effective in promoting balanced use of fertilizer nutrients.

Presentation of Best Farmer Award in the IMPHOS trial by Dr. G. Dev to a leading farmer of Coimbatore District

Several leaflets were produced for each State in local language to spread the results from the project.

One brief example is reproduced below:

Fertilizer P use in Tamil Nadu

Fertilizer use in Tamil Nadu (Table A) has been increasing over the years. However, there is still much scope for increasing fertilizer use in the Tamil Nadu State.

It may be noted that fertilizer use in Tamil Nadu is not in correct and balanced proportion (Table B). P use may be increased along with K to ensure balanced use of fertilizer nutrients.

Phosphorus fertilizers are applied at seeding time and localized in the area that will be exploited by young roots. The following are the best practices to

Table A. Fertilizer Nutrient consumption in Tamil Nadu ('000 tonnes)

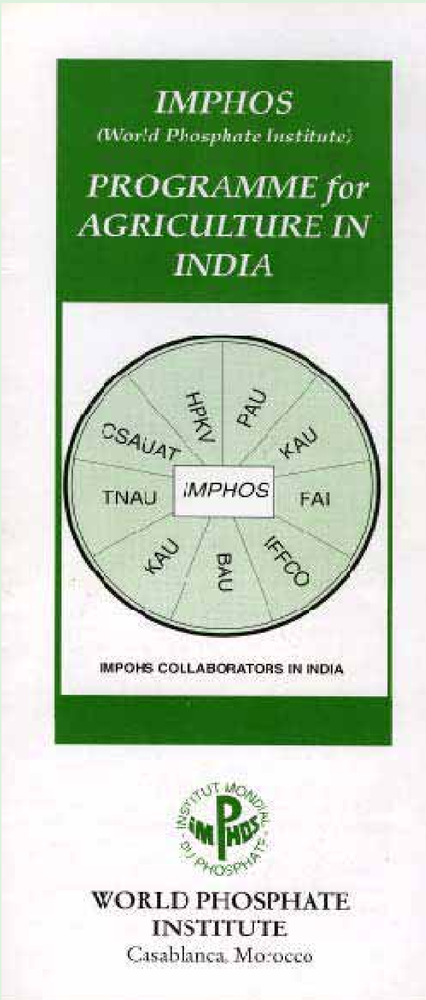
Year	N	P_2O_5	K_2O	Total
1996-97	483.72	145.86	162.21	790.99
1997-98	507.58	194.95	239.98	942.51
1998-99	518.61	202.07	230.21	950.89
1999-00	558.40	224.14	269.40	1051.94
2000-01	547.17	207.94	207.89	963.00
2001-02	509.12	204.86	228.50	942.48

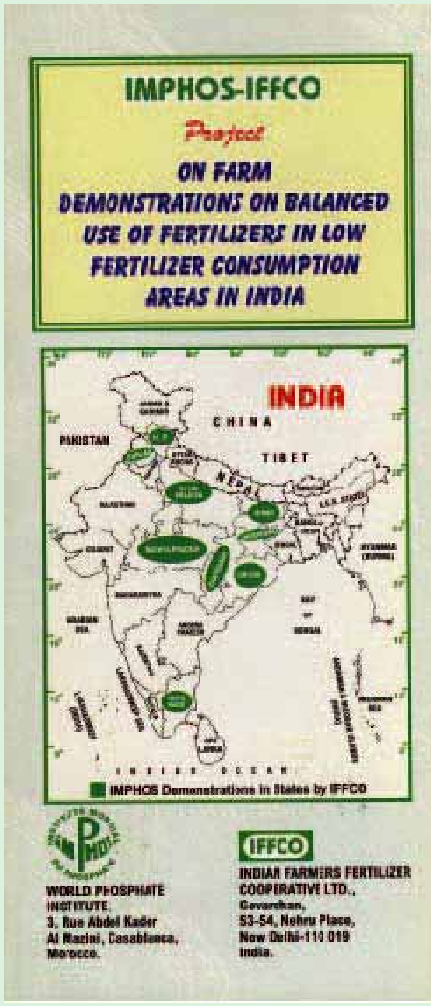
Table B. Fertilizer Nutrient consumption ratio in Tamil Nadu

Year	N	P_2O_5	K_2O	Nutrient use on cropland (kg/ha)
1996-97	3.0	0.9	1.0	112.6
1997-98	2.1	0.8	1.0	150.4
1998-99	2.3	0.9	1.0	151.7
1999-00	2.1	0.8	1.0	158.7
2000-01	2.6	1.0	1.0	145.3
2001-02	2.2	0.9	1.0	142.2

insure that fertilizer P is used efficiently by plants:

- Band application at seeding to the side and slightly below the seed, using tillage equipment or drills.
- Place P fertilizers in soil areas where roots are most active.
- Incorporate into the root zone, 4 to 6 inches deep.
- Lime acid soils to increase pH to levels between 6.5 and 7.0.





Responses of crops and cropping system to phosphorus

Plants can absorb phosphate only when available in ionic form, although organic forms can still be absorbed to some extent. Several research works have been carried out on P responses of crops in Tamil Nadu. The results showed increased rice yield and seed cotton yield; sugarcane yield and sugar yield; sorghum stalk yield and yield of tomato, onion and blackgram, with the application of P as single super phosphate (SSP). In groundnut-fodder maize cropping system, yield of groundnut was increased with P application. P applied to groundnut had also a residual effect on the succeeding crop. The fodder maize had the highest plant height, number of leaves and green fodder yield. It is concluded that P fertilizer use for these crops should be pursued as recommended by Tamil Nadu Agricultural University.

Experiments conducted on farmers fields and soils with low available-P content, covered crops such as groundnut and blackgram at Coimbatore District of Tamil Nadu. The results obtained from using State R&D showed the following records:

- Mean plant height was 46.5 cm on the 90th day compared to 40.0 cm by FP
- Pod yield was 1,900 kg/ha, compared to 1,350 kg/ha by FP, and
- Maximum cost benefit (CB) ratio of 1:3.0 compared to 1:2.4 by FP.

The field experiment on blackgram in farmers fields revealed that the highest pod yield (1,320 kg/ha) and maximum CB ratio (1:4.42) were recorded in treatment which received 125% of state recommended P as SSP compared to the treatment of N application alone (pod yield 900kg/ha; CB ratio 1:366).

Conclusion

Phosphorus fertilization is key element for maximizing yield of all crops. Selection of suitable P fertilizers based on soil test is important. The method of application is critical to achieve efficient use of P nutrient. Balanced use by combination of P with other macro- and micronutrients is important to achieve high yield and increase farm profit ■.

Genotypic Responses of Wheat and Corn to Phosphate Fertilizer *

Within the WANA region, Turkey is a major agricultural country. Even though the agriculture is well developed and very intensive in Central, Western and Southern regions, it is less developed in southeast part of Turkey (GAP region). The GAP will soon be under irrigation by Ataturk dam and therefore soil fertility, irrigation and crop adaptation will need to be conducted before intensive agriculture started. For these reasons, IMPHOS in collaboration with the University of Adana is carrying out since 2002 a project with the objective to promote phosphorus fertilizer use in the GAP and Cukurova regions of Turkey through research work, and extension and farmers activities.

Low natural P level, high P-fixation capacity in clay soils and high $CaCO_3$ content in calcareous soils often create growth-limiting conditions in many areas. Climatic conditions also play a key role in crop production. High fertilizer rates in conjunction with favorable climatic conditions can substantially increase corn and wheat yields. However, the profit from the fertilizers is not permanent under many conditions, and this leads scientists and farmers to grow agronomically valuable P-efficient genotypes. From a practical point of view, genotypes which produce high yield in a low level of P and respond well to added P are the most desirable. Corn and wheat have been dominated crops in Cukurova (southern plain) and the GAP (south eastern part) Regions of Turkey. Many varieties of corn have also been grown as animal feed. Their production especially in the GAP area will be extended in near future by the grand "Irrigation Project" Ataturk Dam. Thus, it is important to establish economically and environmentally sound fertilizer management program before intensive farming.

Shoot dry weight and P uptake in the shoot were determined as ideal plant parameters for screening corn and wheat genotypes for P efficiency under greenhouse conditions. Nutrient uptake, while genetically determined, is affected by the environmental variables and cultural practices.

Genotypic Wheat Response

Locally well known and widely grown wheat genotypes (90% of the total regional production) in the GAP and Cukurova Regions of Turkey were screened for their P efficiency under greenhouse conditions. Even though many plant and root parameters were involved in efficiency, plant dry matter and P uptake were aimed in our study. Fuat-bey, Golia, Adana-99, 1014, Balatilla, Ceyhan-99, Panda, Genc-99, Seri-82 and Firat-93 wheat genotypes were tested on total of previously

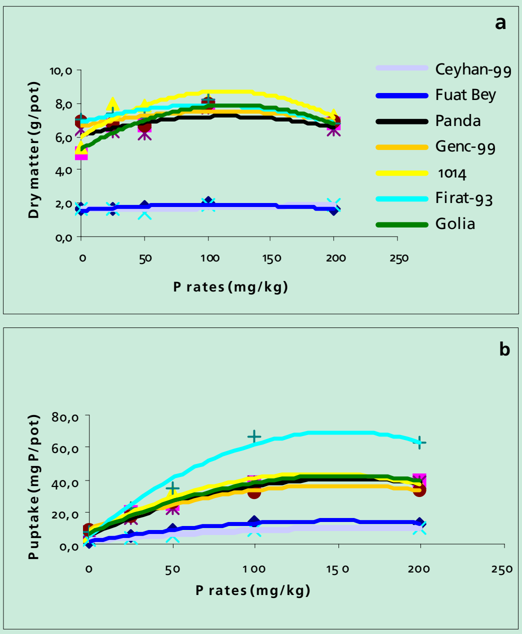


Figure 1. Wheat dry matter and P uptake responses to application rates across the six calcareous series

selected six calcareous soil series of the both regions. As well known, genotypes were classified as efficient-responsive, efficient-nonresponsive, inefficient-responsive and inefficient-nonresponsive. Across the soil series, Fuat-bey and Ceyhan-99 had low amounts of dry matter with 0 P application and not responded to P rates (inefficient-nonresponsive), whereas, Firat-93, Golia and Balatilla (efficient-responsive) had greater dry matter at 0 P application, and their dry matter increased up to 100 mg P kg^{-1} soil application rate (Figure 1a). The other genotypes can be classified as moderately efficient. Even though all the genotypes were not presented in the figures, there was a big dry matter gap among the genotypes (almost 4 times).

One of the plant efficiency parameters P uptake was also determined in this study, and the same genotypes Fuat-bey and Ceyhan-99 had similar response patterns to P rates as that of the dry matters (Figure 1b). Uptake values of almost all genotypes increased up to 150 mg P kg-1 application level and declined beyond that rate.

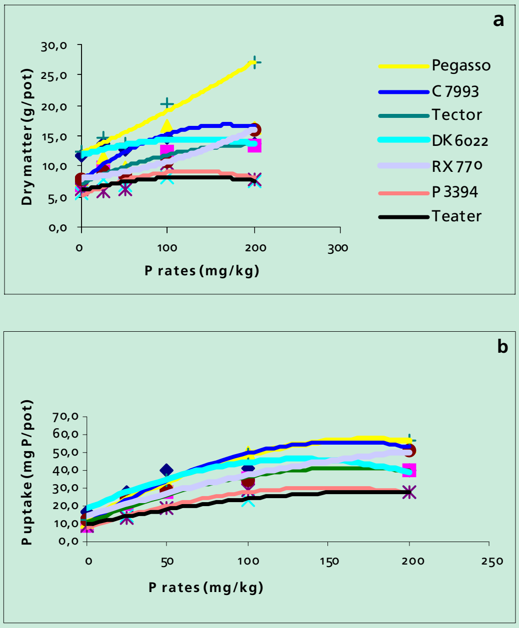


Figure 2. Corn dry matter and P uptake responses to application rates across the three calcareous series

Genotypic Corn Response

Similar to wheat experiment, commonly grown corn genotypes Pegasso, C7993, Tector, DK6022, RX770, P3394, DK585, Sele, DK626 and Teater were screened on the three calcareous GAP soil series under the greenhouse conditions, and the growth conditions of the wheat experiment were similarly applied. Clear genotypic variability was observed among the corn cultivars. Across the soil series, dry matter of P3394 and Teater with 0 P application was the lowest appeared to be inefficient-nonresponsive, whereas, Pegasso and DK6022 (efficient-responsive) had the highest dry matter, differences among the genotypes were almost doubled. Yield of Pegasso linearly increased up to the highest 200 mg P kg^{-1} application level whereas dry matter of the other genotypes peaked about at 100 to 150 mg P kg^{-1} (Figure 2a).

Phosphorus uptake pattern of the genotypes were similar to that of the dry matter, Teater and P3394 taken up less P than the other genotypes. There was three fold P uptake difference between the efficient and inefficient genotypes at 150 mg P kg^{-1}, Pegasso had the greatest response (Figure 2b). The results indicate that plant growth (dry matter) is closely correlated with the plant P uptake.

In this experiment, plant growth and P uptake parameters were significantly increased with increasing P levels up to the certain level. It is appeared to be that plant dry matter and P uptake were important efficiency parameters for genotype screening under greenhouse conditions. Thus, genotypic variability needs to be considered in P fertilizer management ■.

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The International Society of Inorganic Phosphates (ISIP)

At the workshop organized in Jena, Germany, 10-13 July, 2002, on "Phosphates: New uses and New technologies", much interest was expressed among scientists and fertilizer industry specialists who attended the workshop on the relationship between fundamental research on phosphates and its industrial application, between the scientific community working on inorganic phosphates and the industrial entrepreneurs seeking to satisfy the demands of the society. A stronger relationship can benefit both communities and may lead to common ground for promoting a better understanding of the phosphate industry and sound decisions on its products.

In June 2003, the idea emerged at a meeting of scientists at Jena University, Germany, to create ISIP, a non-profit society dedicated to the promotion of science, research, technology and education. Some of the objectives behind this initiative, as declared in the meeting, include:

- Exchanging scientific and technological information through a network of people who share an interest in inorganic phosphates.
- Achieving a better understanding of the various processes affecting inorganic phosphate, including mining, production, industrial processing, recovery and reuse.
- Sustaining environmentally responsible use of phosphates
- Offering a chance for young scientists to be acknowledged
- Promoting scientific and technical education on inorganic phosphates
- Acknowledging outstanding scientific and technical achievements
- Advising government legislative and executive bodies and public welfare institutions on accreditation measures.
- Publishing a journal on phosphate materials and technologies

Last November, at a meeting of the Japanese Association of Inorganic Phosphate Compounds in Kofu, Japan, an international working group was constituted with responsibility for the creation of the Society ISIP, its Board, secretariat, rules, funds,…etc. The formal foundation of ISIP is planned in Japan in September 2005, in connection with convention of the International Symposium on Inorganic Phosphates, to be held at Chubu University ■.

The Fertilizer Industry and the Environment: Fluoride Emission Control (2nd part)

This second part covers fluorine recovery under vacuum, the neutralization and upgrading of the recovered fluorine in the process of phosphoric acid manufacture cited in Newsletter N° 20

Fluorine recovery under vacuum

In this case, once again, the scrubber efficiency should be evaluated on two bases:

- The reaction capacity or the capacity to make gaseous fluoride compounds react with the spray liquid.
- The physical capacity to prevent droplet from evolving from the fluoride acids formed in the reaction phase.

Reaction Efficiency

The "reaction efficiency" is quite easily obtained because the carrier of the fluoride discharges (effluents) consists essentially of water vapor under vacuum, therefore, a large specific volume; the quantity of air or rather that of incondensable products being limited, they do not play practically any role in gas scrubbing, that provokes a partial condensation of the water vapor and the experience shows that this phenomenon is efficient as well as quick.

The fluoride vapor tension in phosphoric acid results from SiF4 volatilization as well as that of HF. The curves of figure 1 show that SiF4 vapor tension is superior to that of HF as the latter tension diminishes during concentration (fig. 2). Sometimes, active silica must be added to facilitate defluoridation of concentrated phosphoric acid. (fig. 2)

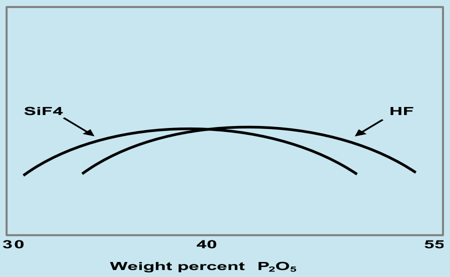


Figure 1: Typical curves showing that SiF4 is evolved before HF during evaporation of wet-process phosphoric acid.

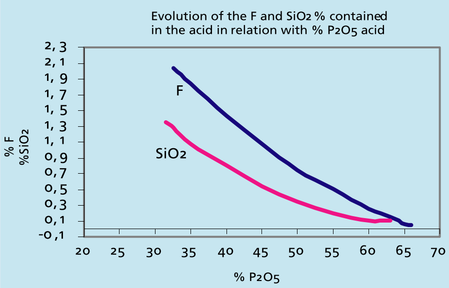


Figure 2: The following sketch shows a typical "F-SiO$_2$" evolution in phosphoric acid

Figure 2 shows that during concentration of wet-process phosphoric acid, SiF4 is evolved first and HF evolution begins later.

In order to obtain a good operational efficiency, the partial pressures of fluorides (SiF_4+HF) of the spray liquid must remain very low; indeed, the concentration of this fluoride liquid expressed in terms of H_2SiF_6 should not exceed 23 to 25%, otherwise, the non-recovered fluorine quantity increases quickly.

The physical efficiency

In contrast, the physical efficiency is not easier to achieve. Indeed, considering the large specific volume of gas and vapors under high vacuum, it is required to transport at high speed in order to limit the size of the equipments (2-4 m/sec in the evaporator, 40-60 m/sec in the connection pipe). At these speeds and despite the low density of the gaseous phase, the entrainments must be large, and this is why resort is made frequently to entrainment separator in order not to lose a good part of the achieved reaction efficiency by mechanical entrainment.

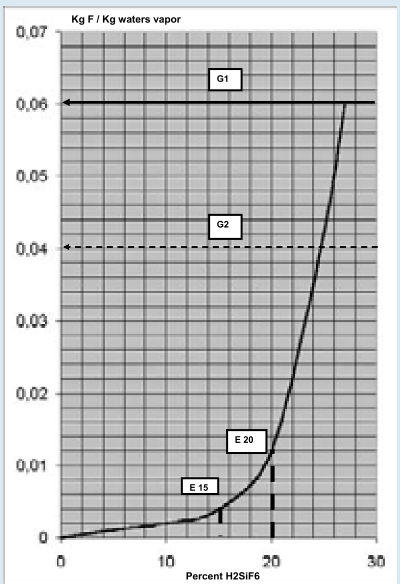


Figure 3: (Equilibrium SiF$_4$)

The superheated vapors from the flash vessel of the phosphoric acid concentration plant first pass through a high-efficiency entrainment separator.

This is essential to reduce the P_2O_5 contamination of the vapors, and thus the product, to a minimum; this is particularly important if the product fluosilicic acid is to meet the purity specifications demanded for certain of its uses.

The collected mixture of dilute phosphoric and fluosilicic acid is sent back to the concentration unit and thus does not represent a loss of either fluorine or P_2O_5.

The cleaned vapors are then fed to a fluorine scrubber, where the silicon tetrafluoride and hydrogen fluoride they contain are absorbed using circulating fluoslicic acid as the scrubbing liquor.

Fluosilicic acid (18%-25%) is withdrawn continuously under density control and the corresponding amount of water is introduced into the system.

For economic reasons, it is desirable to achieve the required fluorine recovery with one scrubber stage only. However, this depends on various factors which need to be carefully investigated before the final decision is made. Whereas the attainable fluorine recovery largely depends on the fluorine content of the incoming vapor as well as the concentration and the temperature of the fluosilicic acid produced, the P_2O_5 content of the fluosilicic acid is mainly dependent on the P_2O_5/F ratio in the vapors from the flash vessel and on the efficiency of the P_2O_5 separator.

Figure 3 shows the fluorine recovery efficiency versus the fluorine content of the vapors for a single-stage scrubbing unit for different concentrations of circulated fluosilicic acid. From this it is quite clear that a high fluorine recovery cannot be achieved with a single-stage unit when a fluorine content of the vapors is low. In that case, a second scrubbed stage would be necessary.

For an existing installation, neither the efficiency of the fluorine absorption unit nor the P_2O_5 content of the fluosilicic acid is constant. They depend rather on the type of phosphate rock processed as well as on the actual operating conditions of the phosphoric acid and concentration plant.

Scrubbing processes used are the following:

- SWIFT process or PARISH
- Improved version of SWIFT process
- SWIFT process improved by Fisons
- PRAYON process
- Alternative USSAC process
- WELLMAN process-INCAN DESCENT

Uses of fluosilicic acid

The recovery of volatile fluoride compounds emitted in the manufacture of phosphoric acid has been made necessary for environmental reasons. Recovery methods have been improved over the past thirty years: the fluoride recovery efficiency increased and the purity of the recovered fluosilicic acid has been improved, wile operation of the recovery equipments has been simplified.

The fertilizer industry discovered that it is endowed with a resource and started planning its use as a source of fluoride in competition with the traditional mineral source, that is Fluorspar, which is concentrated, to the extent of two thirds of world production, in seven countries (Mexico, USA, Spain, South Africa, China, Mongolia, and Thailand).

As the consumption of fluoride in various forms is increasing but its reserves are limited (table 1), some believed that upgrading recovered fluosilicic acid could contribute to the profitability of phosphoric acid production.

Fluoride compounds are sourced from two natural minerals:

- Fluorspar(or fluorine or fluorite)
- Cryolite (including the only deposit in Iceland)

In the 1950 s and 1960 s, the steel industry was the largest consumer of fluoride compounds accounting for more than 50% of production. This figure declined to 30% in the following decade while the chemical industry accounted for more than 60%. The consumption of fluoride in the glass industry, enamellings and ceramics stabilized at 6 to 9%. The increase of aluminum production and particularly the the development of production of fluorocarbons and fluoride polymers that took place between the 1970's and 1980's increased the demand for HF as the raw material for production of AlF_3, $NaAlF_6$ and NaF, salts that are used in the manufacture of aluminum and about 40% of them goes in the production of organic derived products. About 7% of HF is consumed in special uses in metallurgy. The balance is used in the production of catalyzers, special derived products, organic and inorganic products for agriculture, nuclear and electronic industry, and the production of special materials.

Table 1: World fluorine reserves and amounts of minerals mined

Mineral	Main compound	Concentration (% F)	Reserves (million tons)	1990 production (thousand tons)	Ore reserve Years of production
Fluorspar	CaF_2	20 - 40	250.0	9000	20 - 30
Cryolite	Na_3AlF_6	20 - 35	0.7	0.0466	2 - 3
Phosphate	$Ca_{10}F_2(PO_4)_6$	2 - 4	117,000	157,900	700-800

The possible uses of recovered fluorides are the following:

1) Recycling of fluosilicic acid in fertilizer materials such as SSP, TSP, in addition to phosphoric acid.

2) Production of calcium fluoride (CaF_2) which can compete with fluoride from the traditional mineral fluorspar.

3) Production of hydrofluoric acid (HF), sourced from any fluoride compounds.

4) Production of salts used as flux in the production of aluminum, that is to say Na_3AlF_3,NaF.

Neutralization and Disposal of Fluoride Effluents

The fluorine liquid effluents can come from the following sources:

- The liquor from scrubbing the cooling air circulation of the reactors, gas of filters and various vessels. If precaution were not taken, these liquors would be too rich in P_2O_5 and SO_4 to be used.
- The water pond of fluoride-type plants.
- The more or less concentrated solutions of fluosilicic acid originating essentially from the scrubbers located on the reaction evaporators-coolers or the concentration evaporators.

The major disposal methods are the following:

- Use in the washing of the gypsum cake, a solution which increases the content of fluoride and soluble P2O5 content of gypsum in addition to the problem of corrosion.
- Evacuation in the sea or ocean.

In the latter case, the fluosilicic acid is immediately neutralized by the seawater salts as per the equation:

$$2\ NaCl + H_2SiF_6 \rightarrow Na_2SiF_6 + 2\ HCl$$

The result is the production of a hydrochloric acidity that should be dispersed immediately

- Neutralization by calcareous particles in fixed beds.

To avoid products low decantation resulting from the reaction of H_2SiF_6 and $CaCO_3$ in liquid media it is possible to use solution of HF or NH4F to react with calcareous particles in fixed beds.

$$2F^{(-)} + CaCO_3(s) \rightarrow CO_3^{(--)} + CaF_2(s)$$

This process does not insure purification to the extent of obtaining the standard values and there has to be another step, which consists of neutralization by adding lime.

Conclusions and Recommendations

Conclusions

1. It can be concluded from this article that standards for fluorine emissions are well set at the following values:

- Gas emissions: less than 10 mg of F per ton processed P_2O_5
- Liquid effluents: less than 10 g of F per litter of effluent.

2. Considering the most stringent standard used to preserve healthy working conditions, a choice is made among the devices used for scrubbing gas emissions, and only two devices seem to be competitive:

- The systems combining the Venturi and cyclonic tours
- The systems of crossed flux equipped with KIMPRE pads

The latter system is more recent and seems to offer a cost advantage and the possibility of improving performance, which is useful in cases where more stringent standards would prevail.

3. Concerning the recovery of fluorine from the vapors under vacuum, the PARISH process is so well designed that it has survived from one improvement to another and remains very much employed.

While it is based on the same principal, the PRAYON process constitute a breakaway from vapor scrubbing technique and offers a cost advantage in the installation and particularly in usage.

Here again, the astonishing KIMPRE pads could get involved more or less according to success encountered in the ongoing experiences.

4. The direct use of fluosilicic acid solution obtained in the recovery of fluoride is a very difficult problem.

If we consider the direct use of fluosilicic acid or fluosilicates, we realize that the market for such products is not commensurable with the quantities that the primary producers, including IMPHOS member companies, must deal with.

If we consider the direct use as fluoride or fluohydric acid, there are some market segments that are quantitatively significant, but there are also monopolies or oligopolies of producers or users who make this approach extremely risky and full account must be taken of the Florida Institute for Phosphate Research statement: "Do not commit yourself unless you have a good sales contract, even better, a partnership with your buyer".

5. The neutralization of liquid effluents makes use of principles that are unanimously recognized, but which are not yet standardized in a way that we can note differences in modes of implementation as a function of the local conditions.

Recommendations

In the case of investment in new industrial units, it seems wise to recommend the most performing fluoride recovery process among those that are available on the market, but more particularly to plan for possible improvement in the performance as a function of the development of new standards.

To be able to make use of fluoride requires from phosphate producers to enter entirely new technical area where the processes are not yet well known or are not available. In addition, there are oligopolies in this area and extreme care must be taken in order to avoid inopportune investments.

The neutralization of fluorine effluents in the limits defined by the local conditions seems in many cases the wise path to take while hoping for the day when markets can be found for such discharges ■.

Reference:

Etude bibliographique relative à la captation, la neutralisation et la valorisation du fluor: conduite par A. DAVISTER pour le compte de l'IMPHOS

World Agricultural Production and Fertilizer Use: Trends and Prospects

This article aims at providing aggregate data and information on the current situation and trends towards the year 2030 of world agriculture, with a focus on crop production and fertilizer use.

Historical trends of and prospects in food demand and production

The long-term decline in the real price of food suggests that the growth of the productive potential of global agriculture has been more than sufficient to meet the growth of effective demand. In practice, world agriculture has been operating in a demand-constrained environment. This situation has coexisted with hundreds of millions of the world population not having enough food to eat. this situation of un-met demand coexisting with actual or potential plenty is not, of course, specific to food and agriculture, it is found in other sectors as well, such as housing, sanitation and the health services.

Limits on the demand side at the global level reflected three main factors: (i) the slowdown in population growth from the late 1960s onwards; (ii) the fact that a growing share of the world population has been attaining fairly high levels of per capita food consumption, beyond which the scope for further increases is rather limited; and (iii) the fact that those who did not have enough to eat were too poor to afford more food and cause it to be produced, or did not have the resources and other means to produce it themselves.

The first two factors will continue to operate in the future. Their influence will be expressed as lower growth rates than in the past of demand and, at the global level, also of production. The third factor will also continue to play a role, given that the overall economic outlook indicates that poverty will continue to be widespread in the future. It follows that for a rather significant part of world population the potential demand for food will not be expressed fully as effective demand. Thus, the past trends of decelerating growth of demand will likely continue and perhaps intensify.

However, on the production side, there is no assurance that the past experience, when the world's production potential was more than sufficient to meet the growth of demand, will continue, even when demand growth will be much lower than in the past. The natural resources per head of the growing population (e.g. land or water resources per person) will certainly continue to decline and the yield growth potential is more limited than in the past. It remains to be seen whether advances in technology and related factors (e.g. investment, education, institutions and improved farm management) that underpinned the past growth of production will continue to more than make up for the declining resources per person.

In this section a brief overview of expected increases of aggregate demand for, and production of, food products is presented.

At the world level, the growth of demand for all crop products is projected to be lower than in the past, 1.6 % per year in the period 1997/1999-2015 compared with 2.1% per year in the preceding 20 years 1979-1999. The difference between the past and future growth rates of demand is nearly equal to the difference in the population growth rates. However, the past growth rates of demand had been depressed because of the collapse of production and consumption in the transition economies since 1990. The cessation of declines and eventual turnaround of demand in these countries (turning from negative to positive) would have largely offset the effect of lower population growth rate at the global level, at least for the first sub period of the projections. In practice, it is mainly the slowdown in the growth of demand in the developing countries, and in particular in China, that accounts for a large part of the global deceleration. This deceleration in the developing countries outside China (from 3.0% per year in 1979-1999 to 2.4% per year in 1997/1999-2015) is only a little more than the deceleration in their population growth (from 2.2% to 1.7%, respectively), an expected outcome given the operation of the factors mentioned earlier. If the developing countries are grouped into two sets: those that start in 1997/1999 with fairly high per capita food consumption (over 2,700 kcal/person/day) and, therefore, face less scope than before for increasing consumption, and all the rest, that is those with 1997/1999 kcal under 2,700, the following trends can be derived.

China carries a large weight in the former group, so its example can be used to illustrate why a deceleration is foreseen for the developing countries. China has already attained a fairly high level of per capita food consumption of the main commodities, a total of 3,040 kcal/person/day in 1997/1999. In the projections, it increases further to 3 300 kcal by 2030. This is nearly the level of the industrial countries. Going from 3,040 to 3,300 kcal in 32 years is a growth rate of only 0.3% per year. In contrast, in the preceding three decades the average growth rate of per capita kcal was 1.6% per year. Therefore, the higher level from which China now starts imposes a limit on how fast per capita consumption may grow in the future. In addition, China's population growth in the past was 1.5% per year, but in the projection period it will be only 0.5% per year. These numbers vividly demonstrate the combined effects of slower population growth and near-saturation levels of per capita food consumption, in depressing the aggregate growth of demand for food. This deceleration happened in the historical period in countries transiting from low to high per capita consumption and to low demographic growth. For example, the aggregate food demand growth rate of Japan was 4.7% per year in the 1960s and fell progressively to 2.2% in the 1970s, to 2.0% in the 1980s and to 0.8% in the 1990s. When such deceleration occurs in China and in a few other large developing countries, the whole aggregate demand of the developing countries, and indeed the world, will be affected downwards. There are several other developing countries in situations roughly similar to those of China, i.e. they have fairly high levels of per capita consumption and are experiencing a significant slowdown in their population growth. As noted, the first group comprises the developing countries starting with over 2,700 kcal/person/day in 1997/1999. There are 29 of them (including China) but they account for a half of the population of the developing countries, since the group includes many of the largest developing countries in terms of population. They accounted for an even larger share of aggregate consumption of the developing countries in the past, 66% in 1997/1999. As in the case of China, this group of countries has much more limited scope than in the past for increasing per capita consumption, given that the group's average already stands at 3,040 kcal/person/day. This average is projected to grow to 3,300 kcal/person/day by 2030. In parallel, the growth rate of their population is projected to be much slower than in the past, 0.9% per year compared with 1.8% per year in the preceding three decades. The net effect of these demand-limiting factors is that the group's aggregate demand is projected to decelerate, from 4.2% per year between 1969 and 1999, to 1.9% per year in the period to 2015 and to 1.5% per year in the following 15 years to 2030. In contrast, the growth of demand in the other developing countries, those with under 2,700 kcal/person/day in 1997/1999, is projected to decelerate less than their population: the growth rate of their demand falls from 2.9% per year in the preceding three decades to 2.5% per year in the period to 2030, while their population growth rate falls from 2.3% per year to 1.6% per year. This group of countries includes India with its nearly one billion population out of the group's 2.2 billion. The prospect that India will not move much towards meat consumption contributes to limit the growth rate of total demand for both food and feed. In the past, the aggregate demand of the developing countries was greatly influenced by the rapid growth of apparent meat consumption in China.

At the global production level, sufficient production potential can be developed for meeting the expected increases in effective demand in the course of the next three decades. But this is not to say that all people will be food-secure in the future. The interaction between food security and food production potential is very much a local problem in poor and agriculturally dependent societies.

Table 1. Cereal demand and production, world and major country groups

Years	Demand		Production (million t)	Growth rates (% , per year)			
	Per capita (kg*)	Total (Million t)		Period	Demand	Production	Population
World							
1964-66	283	941	940	1969/99	1.9	1.8	1.7
1974-76	304	1,233	1,268	1979/99	1.4	1.4	1.6
1984-86	334	1,608	1,659	1989/99	1.0	1.0	1.5
1997-99	317	1,864	1,889	1997/99-2015	1.4	1.4	1.2
2015	332	2,380	2,387	2015-2030	1.2	1.2	0.9
2030	344	2,830	2,838	1997/99-2030	1.3	1.3	1.1
Developing countries							
1964-66	183	419	399	1969/99	3.0	2.8	2.0
1974-76	200	586	563	1979/99	2.6	2.5	1.9
1984-86	234	840	779	1989/99	2.2	2.1	1.7
1997-99	247	1,129	1,026	1997/99-2015	1.9	1.6	1.4
2015	265	1,544	1,354	2015-2030	1.5	1.3	1.1
2030	279	1,917	1,652	1997/99-2030	1.7	1.5	1.3
Industrial countries							
1964-66	483	335	351	1969/99	1.0	1.5	0.7
1974-76	504	384	456	1979/99	1.0	0.8	0.7
1984-86	569	464	614	1989/99	1.7	1.4	0.7
1997-99	588	525	652	1997/99-2015	0.8	1.1	0.4
2015	630	600	785	2015-2030	0.6	0.9	0.2
2030	667	652	900	1997/99-2030	0.7	1.0	0.3
Transition countries							
1964-66	556	186	189	1969/99	-0.2	-0.3	0.6
1974-76	719	263	249	1979/99	-1.9	-1.1	0.5
1984-86	766	304	266	1989/99	-4.9	-4.2	0.1
1997-99	510	211	210	1997/99-2015	0.7	1.0	-0.2
2015	596	237	247	2015-2030	0.7	1.0	-0.3
2030	685	262	287	1997/99-2030	0.7	1.0	-0.2

Unless local agriculture is developed and/or other income earning opportunities open up, the food insecurity determined by limited local production will persist, even in the middle of potential plenty at the world level. The need to develop local agriculture, as the condition sine qua non for improved food security, cannot be overemphasized.

Cereals: past and present demand trends

Cereals continue to be overwhelmingly the major source of food supplies for direct human consumption. In addition, some 660 million tones of cereals, or 35 % of world consumption, are being used as animal feed. Therefore, the growth of aggregate demand for cereals for all uses is a good (though far from perfect) proxy for monitoring trends in world food supplies.

Historically, the growth rate of global demand for cereals (for all uses) has been in long-term decline (Table 1). The world growth rate declined progressively from 3.1% in the first 15-year period (1961-1976) to 1.1% per year in the last 15-year period ending in 1999.

The deceleration in population growth certainly played a role in this slowdown, as has the fact that a growing proportion of the world population has been gradually attaining levels of per capita food consumption that leave less scope than in the past for further increases. However, these two factors explain only part of the decline, given that there are still grossly unsatisfied nutritional needs affecting large part of the world population.

Prospects for the cereal sector

The decline in world per capita production and consumption of cereals that occurred in the decade following the mid 1980s was interpreted as foreshadowing an impending world food crisis. However, this trend will reverse and the reversal has already started.

World per capita production peaked at 334 kg in the mid-1980s and declined to the current 317 kg.

In the projections made, the declining trend is reversed and world per capita cereal consumption will rise again and will reach 332 kg in 2015, and 344 kg in 2030. Aggregate consumption of all cereals should increase by 2030 by nearly one billion tonnes from the 1.89 billion tonnes of 1997/1999 (Table 1). Of this increment, about 50% will be for feed, and 42% for food, with the balance going to other uses (seed, industrial non-food, etc).

Table 2. Fertilizer consumption by major crops

Crops	1997/1999 share (%)	1997/1999	2015	2030	1997/1999-2030 % per year
		nutrients (million tons)			
Wheat	18.4	25.3	30.4	34.9	1.0
Rice	17.3	23.8	26.5	28.1	0.5
Maize	16.3	22.5	29.0	34.5	1.3
Fodder	6.2	8.5	9.3	10.0	0.5
Seed cotton	3.5	4.9	6.2	7.1	1.2
Soybeans	3.4	4.6	7.6	11.5	2.9
Vegetables	3.3	4.6	5.3	6.1	0.9
Sugar cane	3.2	4.4	5.5	6.6	1.3
Fruit	2.9	4.1	4.3	7.5	1.9
Barley	2.9	4.0	4.4	4.8	0.6
Other cereals	2.9	3.9	9.2	8.3	2.3
Potato	2.0	2.7	3.3	3.8	1.1
Rapeseed	1.5	2.1	3.5	5.1	2.8
Sweet potato	1.3	1.8	2.0	2.1	0.5
Sugar beet	1.0	1.4	1.6	1.7	0.6
All cereals		79.5	99.5	110.6	1.0
% of total	57.7	57.7	64.8	58.8	
All crops		118.5	148.2	172.1	1.2
% of total	86.0	86.0	89.8	91.5	
World total		**137.7**	**165.5**	**188.0**	1.0

Feed use will revert to being the most dynamic element driving the world cereal economy, in the sense that it will account for an ever-growing share in aggregate demand for cereals. It had lost this role in the last decade following the above-mentioned factors that affected feed use in two major consuming regions, the transition economies and the EU. Feed use had contributed only 14% of the total increase in world cereal demand between the mid-1980s and 1997/1999, down from the 37% it had contributed the decade before.

Crop production and fertilizer consumption

The bulk of the projected increases in crop production will have to come from higher yields, with the remaining part coming from an expansion in harvested area. Both higher yields, which normally demand higher fertilizer application rates, and land expansion will lead to an increase in fertilizer use. Increases in biomass require additional uptake of nutrients, which may come from both organic and mineral sources.

The historical relationship between cereal production and mineral fertilizer consumption is better known. One-third of the increase in cereal production worldwide and half of the increase in India's grain production during the 1970s and 1980s have been attributed to increased fertilizer consumption. The application of mineral fertilizers needed to obtain higher yields should complement nutrients available from other sources and match the needs of individual crop varieties. Increased use of fertilizer is becoming even more crucial in view of other factors, such as the impact on soil fertility of more intensive cultivation practices and the shortening of fallow periods.

Farmers are achieving increased nutrient use efficiency by adopting improved and more precise management practices. It is expected that this trend of increasing efficiency of nutrient use through better nutrient management, by improving the efficiency of nutrient balances and the timing and placement of fertilizers, will continue and accelerate in the future.

Projections for fertilizer consumption have been derived on the basis of the relationship between yields and fertilizer application rates that existed during 1995/1997. Data on fertilizer use by crop and fertilizer application rates (kg of fertilizer per ha) are available for all major countries and crops, accounting for 97% of global fertilizer use in 1995/1997. This relationship is estimated on a cross-section basis for the crops for which data are available and is assumed to hold also over time as yields increase. It provides a basis for estimating future fertilizer application rates required to obtain the projected increase in yields for most of the crops covered in this study. It implicitly assumes that improvements in nutrient use efficiency will continue to occur as embodied in the relationship between yields and fertilizer application rates (fertilizer response coefficients).

The overall result, aggregated over all crops, is that fertilizer consumption will increase by 1.0 % per year, rising from 138 million tonnes in 1997/1999 to 188 million tonnes in 2030 (Table 2). This is slower than in the past for the reasons explained below.

Wheat, rice and maize, which together at present account for over 50% of global fertilizer use, will continue to do so, at least until 2030. By 2015 maize will rival wheat as the top fertilizer user because of the projected increase in maize demand for feeding purposes in developing countries. Fertilizer applications to oilseeds (soybeans and rapeseed) are expected to grow fastest.

North America, Western Europe, East and South Asia accounted for over 80% of all fertilizer use in 1997/1999. Growth in fertilizer use in the industrial countries, especially in Western Europe, is expected to lag significantly behind growth in other regions of the world. The maturing of fertilizer markets during the 1980s in North America and Western Europe, two of the major fertilizer consuming regions of the world, account for much of the projected slowdown in fertilizer consumption growth. In the more recent past, changes in agricultural policies, in particular reductions in support measures, contributed to a slowdown or even decline in fertilizer use in this group of countries.

Over the past few decades, the use of mineral fertilizers has been growing rapidly in developing countries starting, of course, from a low base. This has been particularly so in East and South Asia following the introduction of high yielding varieties. East Asia (mainly China) is likely to continue to dwarf the fertilizer consumption of the other developing regions. For sub-Saharan Africa, above average growth rates are foreseen, starting from a very low base, but fertilizer consumption per hectare is expected to remain at a relatively low level. The latter probably reflects large areas with no fertilizer use at all, combined with small areas of commercial farming with high levels of fertilizer use, and could be seen as a sign of nutrient mining ■.

SOURCE: Excerpts from "World Agriculture: towards 2015/2030 An FAO Perspective" Edited by Jelle Bruinsna, EARTHSCAN Publication Ltd, 2003.

Constraints and Opportunities for Phosphorus Use in Germany*

Phosphorus is the first non renewable resource, which will become scarce within relatively short period of time (60-130 years). The strongest demand for phosphorus comes from agriculture, which at the same time is the most important source of P losses to water and the environment.

Phosphorus is an essential element for all living organisms. The most important entry into the food chain is by plants, which take up P preferably in the form of water soluble orthophosphate. Therefore, it is generally recommended, with regard to an economical use of this limited resource, to apply mineral P fertilizers that are soluble in water or citric acid.

Symptoms of P deficiency in plants are rarely observed in Germany these days. The maintenance of an optimum P supply is of prime interest. To determine the P demand of farm crops and optimise fertilization strategies from an economic as well as ecological point of view, the concept of fertilization based on off-take by harvested produce can be applied if the P supply is in the sufficiency range. If the plant-available P content of soils is, however, above 100mg/kg P_{CAL}, no further fertilizer should be applied until the soil P content decreases below this threshold level. Furthermore, it is crucial to take into account the spatial variability of soil P when testing soils for their nutrient status. The concept of monitoring pedocells has been developed in the Institute of Plant Nutrition and Soil Science for the purpose of minimizing sampling efforts and recording simultaneously information on spatial and temporal changes of relevant soil characteristics.

Organic farms are facing a particular challenge, as the directives of organic farming associations do not allow for the application of readily soluble P forms. Thus, there is a significantly high risk of depletion of plant-available P in soils (nutrient mining) subjected to organic farming. In order to optimise the P supply, organic farmers therefore, must count on alternative strategies such as establishing legumes, cover crops and other deep-rooting crops as part of a diversified crop rotation system. Another option is breeding and selection of plant species with a higher P absorption capacity and utilization efficiency. Apart from animal manures, organic farmers may rely on ground rock phosphate for fertilization. The FAL-Institute of Organic Farming in Trenthorst reported on joint experiments with the Institute of Plant Nutrition and Soil Science, where granules consisting of rock phosphate and elemental sulfur (both minerals may be used in organic farming) were combined with thiobacilli. These bacteria obtain their energy from oxidation of sulfur, forming sulphuric acid and releasing plant available P in the process.

The evaluation of mineral as well as organic P fertilizers such as sewage sludge and animal manures is focussed on undesirable substances in fertilizers. While a number of heavy metals are regulated in the new German ordinance for mineral fertilizers, the majority of (potentially) harmful organic substances in animal manure remain unaccounted for in a legal sense. Even the ordinance on sewage sludge and organic wastes accounts for only a few of the many organic substances known today. As sewage sludges are a mixture of residues from domestic and industrial waste waters, many scientists advise the mono-incineration (i.e. the separate incineration, no mixed burning with any other substances) of sludge and the subsequent recovery of P from the ashes as this is the only sustainable utilization of waste products.

An overview of the significance of heavy metals in organic and mineral P fertilizers concluded that some rock phosphates used for mineral P fertilizer production may contain traces of cadmium and uranium. As more than 75% of heavy metals taken up by humans are ingested with vegetables, this food crop plays an important role in human health. The toxic effects of heavy metals on animals and humans and the very complex process of risk assessment and management were reviewed. To restrict the heavy metal inputs into soils, the German Minister of agriculture and environment made the decision in Potsdam in 2001 that, following the principle of precaution and in view of the important role of agricultural soils in the production of healthy food, an accumulation of harmful substances in soils due to cultivation practices such as the application of sewage sludge, slurry and farmyard manures, mineral fertilizers or compost is not acceptable. Accordingly, scientists of the Institute of Plant Nutrition and Soil Science (FAL) expressed their opinion that the only logical consequence would be that farmers not only calculate nutrient balances, but also balance harmful substances such as heavy metals on farm level. In order to keep the current "status quo" of harmful substances in their soils, farmers need detailed information about their concentration in the mineral and organic fertilizers in order to select an appropriate P source.

An important ecological hazard related to unbalanced P fertilization is the eutrophication of surface waters. Not only fertilization must be according to the requirement of the plant, it is also most crucial for farmers to keep a sound balance between livestock density and available cropland area in order to prevent a regional overload of farmyard manure on agricultural lands.

P balances are useful tool to control the P losses to surface waters. The highest P surplus in Germany occurs in areas with high livestock density. On the other hand, Nutrient budgets for arable farms do not show a considerable surplus in general. Feed imports from countries with a negative P balance such as China or Vietnam further contribute to the problem of P surplus and P deficiency in the respective import and export countries ■.

**This article is based on a report by Dr. Sylvia Kratz (email: pb@fal.de) bearing the title: "P Information day at FAL". The report covers a nutrient Workshop held on November 27, 2003, at the Institute of Plant Nutrition and Soil Science, Bundesallee 50, D-38116 Braunschweig, Germany.*

Positive Nutrient Management for the Fertilization of Lakes, River and Marine Ecosystems

Fertilizing the Sea

Through artificial fertilization of coastal water, primary marine production (algae or zooplankton/Shellfish) could be increased, which leads in turn to marine food production increase.

The general strategy is to increase primary marine production, by generating artificial upwelling, an upward water movement, which can bring nutrient-rich deep waters up to the light, enabling primary production (zooplankton…etc.) near the water surface. Alternatively, the increase can be achieved through fertilization by adding nutrient input. This strategy has the potential to increase primary marine production by a factor of 3 to 4 times.

The trophic levels in fisheries are as follows:

Level 1: algae

Level 2: zooplankton, (eg. Krill) shellfish

Level 3: fish, e.g. herring

Level 4: fish, e.g. halibut, turbot

Level 5: fish, e.g. tuna, squid

The increased primary productivity is fairly reliably related to overall increased fishery productivity, but their effects in a given region or on a given fish species are less predictable, because of fish movements and species interactions.

Addition of Nutrients Addition of Fertility and Shellfish Growth

Hopavagen Bay, on the central Norway coast, (69° 35′ N, 09° 30′ E), is an enclosed water of 370,000 m^3, mean depth 18 cm, connected to the open North Sea by Shallow, narrow Chennel (1m deep at low tide). Algal biomass production and growth of blue mussels (*Mytilus edulis*) an escallops (Pecten maximums) were analyzed at various depths over three years (1997-1999), with nutrients (nitrogen, silicon and phosphorus) being added during the second two years A control site on the open coast was also monitored for comparison (no nutrient addition).

Nutrients were added in 1998 at a rate estimated to be twice the natural supply (0.4 μg P/l/day, N:Si:P ratio of 15:5:4.1) and in 1999 at three times the natural supply (0.8 μg P/l/day, N:Si:P ratio of 16:8:1). Nutrients were added through separate dosing channels to avoid reactions leading to precipitation.

The results of nutrient addition are cited below:

- Increases in mussel and scallop productivity
- Nutrient addition in 1999 resulted in 50% increase in mean summer algal biomass in the Bay and a doubling of primary production.

The authors conclude that fertilizer addition has a positive effect on scallop growth in this marine environment.

In other studies and field work carried out in a number of countries, attempts were made to restore the salmonid population in lakes, rivers and streams by artificial addition of phosphorus and nitrogen, in order to balance reduction of anthropogenic oligotrophication and to help fish populations recover from other pressures, such as over fishing or habitat destruction (dam construction, loss of wetlands and spawning grounds).

Studies have shown significant positive effects are achieved on fisheries productivity and salmonid and trout population restoration, while appropriate management enables ecosystem equilibrium to be maintained.

Nutrient Supplementation for Salmonid Restoration at Redfish lake Idaho,USA

Redfish lake is one of five pre-alpine lakes in the Sawtooth Valley, Southern Idaho, in the headwaters of the Salmon River (44° N, 115° W), which itself flows into the Snake River and this in turn into the Columbia River. Redfish is situated at 1996 m altitude, with a surface of just over 6 km^2, a mean depth of 44m and a residence time of 3 years. The smaller Stanlgy lake was monitored for reference, being chosen because it was not receiving nutrient addition for fish stocking.

Fertilizer Addition: Liquid ammonium phosphate and ammonium nitrate were added weekly for five years to Redfish

Lake throughout the growing season in 1995-98, at approximately 45:1 N:P molar ratio (the high N:P ratio being intended to avoid nuisance blue – green algae). Consent authorized fertilizer addition unless transparency fell down 8m Secchi depth, chlorophyll-a exceeded 6-6 µg/l or total phosphorus exceeded 15 µg/l: these conditions were always respected during the five years and nutrient addition proceeded without interruption.

Phytoplankton increased and primary production was positively correlated to nutrient addition, but phytoplankton communities remained typical of oligotrophic conditions, dominated by small readily – grazable microglagellates.

Although it was not possible to establish clear links between primary production and food chain effects, it was noted that the total zooplankton biomass increased by 31% (compared to stable levels in the unfertilized Stanley lake) and Daphnia (key salmonid food) increased by 225%. Salmon populations also showed improvements with fertilization: density increased by 26% and overwinter survival by 192%.

It was also noted that there were no apparent declines in water quality with fertilization, and that numbers of salmon spawning on the lake's beaches (residual salmon) did not increase (fertilization did not appear to be leading to a reduced tendency to migrate).

The authors conclude that nutrient addition is a useful tool for supporting salmonid populations during restocking programs, without any apparent negative effects, and that further research is necessary into the role of microbial food webs in the use and transfer to fresh populations of primary productivity■.

Source: SCOPE Newsletter #53

FLASH

Crop Fertilization in Argentina

The situation before 1990

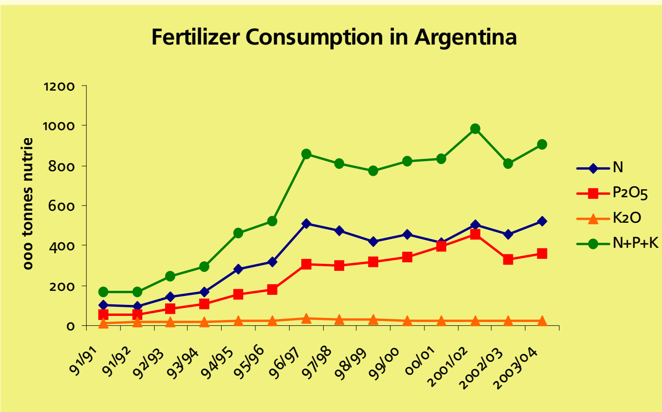
The level of crop production that had prevailed in Argentina had not required much fertilization. Extensive lands of fertile soils provided sufficient nutrients for cultivated crops and natural pastures. Argentina was best known for cattle raising on its pastures, and in 1960 it accounted for one third of the world's export of beef and veal.

For many years, profitable cereal exports were subject to heavy taxation, with custom duties in 1989 ranging from 30 to 40% of the sales value. On the input side, import duties on fertilizers and agrochemicals amounted to 65% of their market value, resulting in major domestic market supply by the national fertilizer industry, which is protected by fertilizer import duties. The outcome of this policy is an unfavourable ratio of crop value to fertilizer cost for the farmer and little incentive for fertilizer use.

However, with the increasing intensification of agriculture and falling level of soil fertility, responses to fertilizer nutrients became evident for many crops, especially when grown on soils cultivated for long periods of time, and subsequently depleted of soil organic matter and nutrient contents. Meat exports almost ceased and nearly all meat was consumed domestically.

The situation in the 1990's

A major policy change occurred in 1990. The removal of custom barriers protecting the national fertilizer industry, opened the way for large imports and use of fertilizer. Furthermore, levies on imports of cereals were abolished in 1991, and production became more attractive. As a result, the use of fertilizers and the development of direct seeding were the most important technical changes in the 1990's concerning the principal crops of soybean, maize and wheat. It was on wheat that farmers observed the advantages of fertilization, then on maize. Pasture, especially temporary pastures, were the third sector to be fertilized. Sunflower and especially soybeans response to fertilizers was less apparent. In contrast, the technical innovations that resulted in large increases in soybean production in the Pampa region were the sowing of herbicide resistant varieties of soybeans and direct sowing. Fertilizer consumption rose fivefolds between 1990 and 1996, from 165,000 to 855,000 tonnes nutrients. Cereals, mainly wheat and maize, accounted for almost 60% of fertilizer consumption. With oilseed crops and pastures, they account for 80% of fertilizer consumption.



Shortly after removal of custom duties, average production of cereals and soybean, which was 29 million tonnes between 1989 and 1991, rose to over 50 million tonnes by the end of the decade. Argentina suddenly became the third largest exporter of soybeans and maize in the world and the fourth largest exporter of wheat.

Over the same period, the cropland under pressure irrigation systems (sprays, drip and similar irrigation systems), mainly fruit and horticultural croplands, expanded at an exponential rate.

Wholesalers and retailers were increasingly offering farm services, including the offer of fertilizers in bulk and blends. A nationwide system for agricultural education, research and advisory services facilitated the transfer of new technologies.

Argentina plans to increase its soybean production from 74 to 100 million tonnes by the year 2013, which means an annual growth rate of 3% will be required. This growth should come from an increase in both the sown area and the soybean yield. For the coming ten years, the yield should increase at an average rate of 2% per annum, which translates into a cumulative growth of 588 kg/ha, or a yield target of 3,333 kg/ha. That yield target would be achieved through biotechnology and increased fertilization■.

Fertilizer Use Efficiency

Fertilizer use efficiency is receiving increased attention because of growing pressure for agriculture to minimize negative environmental impacts. With nitrogen, both **recovery efficiency** (increase in uptake per unit nutrient added) and **agronomic efficiency** (crop yield increase per unit nutrient added) are useful terms. Research on farm fields in the U.S. and Asia show that recovery efficiency for fertilizer N is usually below 50% and frequently below 40% illustrating significant opportunity for improvement. Increased adoption of existing and new technologies will likely allow yields to continue to increase faster than N use for the foreseeable future, leading to higher agronomic efficiency.

Applying the concept of agronomic efficiency as presented above to P and K is problematic because highest "efficiency" occurs when inadequate amounts are applied at low soil test levels associated with reduced profitability, reduced water use efficiency, reduced N use efficiency, and reduced land use efficiency. Where significant reserves of nutrients can accumulate in the soil, as is the case for P and K, the concept of **sustainable efficiency** is more useful. Sustainable efficiency is the nutrient input needed to sustain the system at optimum productivity. Sustainable efficiency will translate into increased P and K demand in some areas, while in areas with significant livestock concentration, it will mean reduced fertilizer demand ■.

Source: Excerpts from a paper by David W. Dibb, Paul E. Fixen, and Mark D. Stauffer, PPI and PPIC. The paper was given at the 71st IFA Annual Conference, May 2003, under the title: "Fertilizer Use Efficiency: the North American Experience".

Traditional Nutrient Efficiency Terms

- Recovery efficiency (RE) = Increase in uptake per unit nutrient added usually expressed as %.
- Agronomic efficiency (AE) = Crop yield increase per unit nutrient added such as kg grain/kg nutrient

Areas of opportunity for improvement in fertilizer N efficiency

- Continued improvement in cropping system management
- Realistic estimation of attainable yield
- Yield potential protection – pest management and other cultural practices
- Balanced nutrition
- Use of site-specific precision ag technologies
- Better prediction of soil N mineralization
- Improved timing of N application
- Improved manure management and crediting
- Improved fertilizers
- Biotechnology?

We need to view P and K efficiency as different than N efficiency

A.E. Johnston and P Poulton

"The difference method (RE) is appropriate for N but is less useful for P and K where plant available reserves of these nutrients can accumulate in the soil from past applications of fertilizer."

Sustainable efficiency (for P&K) – Nutrient input needed to sustain the system at optimum productivity expressed as a removal to use ratio.

If a field is at its optimum soil test level, and replacement of the P and K removed by crops maintains that optimum level,

what is the efficiency of P or K?

100%

If use must exceed removal to maintain optimum productivity, soil erosion or fixation are often the cause:

- Reduce erosion losses
- Utilize banding and annual fertilizer application

Impact of Improving Efficiency on Fertilizer Demand

Critical to properly define efficiency for the nutrient in question

Nitrogen

- Good progress has been made in improving agronomic efficiency
- Will be significant pressure to further improve agronomic efficiency without sacrificing yield potential
- Research shows there is room for improvement
- Yields will likely continue to increase faster than N use

Phosphorus and potassium

- Increasing pressure to improve system efficiency by reducing P levels where excessive.
- Sustainable efficiency will translate into increased P and K demand in some major production regions.
- Pressure to improve N efficiency should result in increased support for balanced nutrition with P and K
- Higher future crop yields could require higher target soil test levels and temporarily impact demand
- The thermodynamic need to replace P and K removal at some soil level sets a lower limit for P and K use

As food needs increase … fundamentals of natural systems indicate a permanent and expanding role for fertilizers in food production

Examples of apparent recovery efficiency of P fertilizer in long term studies

Soil(s)	Applied P_2O_5 (Kg/ha)	No. of crops		% Recovery
Calcareous clay	67	5	F	28
Clay loam, pH= 7.3	29	9	F	54
28 soils, pH 6.2-7.9	152	8	GH	74
4 soils, pH 6.7-7.6	230	19	GH	87
Sandy loam, non-calcareous	118	4	F	100

COMING EVENTS

For more information about the upcoming fertilizer related events, please contact directly the indicated organizers

24 - 28 November 2004

Regional Workshop on Potassium and fertigation Development in the West Asia and North Africa Region

Rabat, Morocco
Fax: + 33 3 21 06 40 05
Email: michel.marchand@tessenderlo.com
www.ipipotash.org

1 - 3 December 2004

30th IFA Enlarged Council Meeting Preceded by the Atacama Tour 2004

hosted by SQM, Santiago, Chile
Tel: 331 53 93 05 00
Fax: 33 1 53 93 05 45
Email: ifa@fertilizer.org
www.fertilizer.org

8 - 10 December 2004

2004 FAI Annual Seminar

New Delhi, India
Fax: + 91 11 696 00 52
Email: General@faidelhi.org
www.faidelhi.org

8 - 10 December 2004

2004 IFS Conference on Micronutrients

Cambridge, UK
Fax: + 44 1904 492700
Email: secretary@fertiliser-society.org
www.fertiliser-society.org

14 - 16 December 2004

IFA Regional Conference for Asia and the Pacific

Auckland, New Zealand
Tel: 331 53 93 05 00
Fax: 33 1 53 93 05 45
Email: ifa@fertilizer.org
www.fertilizer.org

28 January - 1st February 2005

International Conference on Soil, Water and Environmental Quality, Issues and Strategies

New Delhi, India
Fax: + 91 11 258 41529
Email: isss@vsnl.com
www.isss-india.org

30 January - 4 February 2005

9th International Symposium on Soil and Plant Analysis (ISSPA)

Cancún, Mexico
Fax: + 49 6307 401104
Email: palmmail@convservices.de
www.spcouncil.com

1 - 3 February 2005

AFA 11th International Annual Conference

Cairo, Egypt
Fax: + 20 2 417 2347
Email: info@afa.com.eg
www.afa.com.eg

16 - 18 March 2005

3rd New Ag International Conference and Exhibition

Antalya, Turkey
Fax: + 44 20 8744 1705
Email: exhibitions@newaginternational.com
www.newaginternational.com

14 - 19 September 2005

15th International plant Nutrition Colloquium (IPNC)

Beijing, China
Fax: + 86 10 62891016
Email: ipnc2005@cau.edu.cn
www.ipns15.com

22 - 26 October 2005

3rd «Silicon in Agriculture» Conference

Uberlândia, Brazil
Fax: + 55 34 32182225
Email: ghk@triang.com.br
www.siliconinagriculture.iciag.ufu.br

If you know of any other conferences or events related to plant nutrition or fertilizer use, please inform IMPHOS.

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 increase and sustain agricultural production, and to meet the food requirements of humankind 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 in Africa and Asia, IMPHOS is conducting several projects to demonstrate the need to supply phosphate to increase and sustain food production. In phosphorus enriched soils, 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.

IMPHOS MEMBER COMPANIES

IMPHOS MEMBER COMPANIES

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7-9 rue du Royaume d'Arabie Saoudite
1002-TUNIS, Tunisia
Tel: 216 71 784 488/799 934/797 296
Fax: 216 71 793 685
Web site: http://www.cpg.com.tn

Industries Chimiques du Sénégal (ICS)

Km 18 Route de Rufisque-M Bao
BP. 3835, DAKAR, Senegal
Tel: 221 8 34 01 22/34 21 23/34 01 23/34 08 14
Fax: 221 8 34 07 01
Web site: http://www.ics.sn/ics-coop.htm

Groupe Office Chérifien des Phosphates (OCP)

Angle route d'El Jadida et bd. La Grande Ceinture
CASABLANCA, Morocco
Tel: 212 22 23 00 25/23 10 25/23 01 25/23 30 25
Fax: 212 22 23 06 35
Web site: http://www.ocpgroup.ma

EPE FERPHOS

Zhun II, BP. 122, Djebel El Jorf
TEBESSA 12000, Algeria
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Fax: 213 37 49 43 50/49 25 50

Jordan Phosphate Mines Co. Ltd (JPMC)

PO Box 30
AMMAN, Jordan
Tel: 962 6 560 70 10/6 560 71 41/6 560 70 19
Fax: 962 6 5 68 22 90/65 691290
Web site: http://www.jordanphosphate.com

International Fertilizer Group-Togo (IFG-TG)

BP. 379, LOME, Togo
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