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M

OFFICE MEMORANDUM

TO: Mr. Montague Yudelman, AGPDR　　DATE: May 8, 1974

FROM: Joris J. C. Voorhoeve, AGPDR

SUBJECT: Note on the Proposed International Plant Nutrition Institute

1. The American Secretary of State recently proposed to the U.N. General Assembly "the establishment of an international fertilizer institute as part of a larger effort to focus international action on two specific areas of research: improving the effectiveness of chemical fertilizers, especially in tropical agriculture, and new methods to produce fertilizers from non-petroleum resources.1/ Subsequently, the proposal has been broadened into a suggestion for the establishment of an international plant nutrition institute.

2. The purpose of the Institute appears to be to find ways to achieve the following:

(1) to increase total fertilizer production;

(2) to reduce the energy costs of fertilizer production;

(3) to raise the effectiveness of fertilizers;

(4) to increase the recovery of plant nutrients in organic wastes;

(5) to increase biological nitrogen fixation and microbial dissolution of plant nutrients.

Apart from the coordination and execution of the research which is necessary to achieve these five purposes, the institute may store and disseminate information, and train scientists and extension workers.

3. The purposes (1), (2), and (4) have recently been analyzed in the Bank Group's Fertilizer Policy and Program as prepared by IFC.2/ This note highlights again some points made in IFC's analysis and discusses other possible avenues to increase the supply of nutrients to crops.

I. Raising the Effectiveness of Fertilizers

4. Presently, only a part of the total fertilizer production is utilized effectively. Plant nutrients are lost in storage and transportation, particularly of urea in humid tropical conditions. Obviously, these losses can be reduced by correcting the technical and organizational flaws in national, regional, and local systems of fertilizer distribution.

1/ Henry A. Kissinger, "Challenges of Interdependence," Address Before the Sixth Special Session of the United Nations General Assembly at New York, Department of State News Release, April 15, 1974, pp. 5-6.

2/ Document PRC/M/74-5.

5. Once applied to the soil, about 50 percent of the nitrogen disappears through leaching, gasification, or biological transformation. Potash is leached to some extent too. Particularly on acid soils, phosphates are partially transformed into insoluble salts, which may again become available to subsequent crops, however.

6. The degree to which nutrients are lost after soil fertilization depends mainly on rainfall, cropping pattern, temperature, the chemical and physical nature of the fertilizer product, and the mode of fertilizer application. Losses can be reduced by using coated, slow-release fertilizer pellets, by correction of chemical soil deficiencies (e.g., pH adjustment), by improvement of soil structure through better tillage methods, by placing the fertilizer below the surface, by cover-cropping during fallow periods, and by a greater application of green and organic manures. Whereas the fertilizer potential of organic wastes and manures is very large (see Annex I), it is very difficult to expand green manuring in the tropics. Where the man/arable land ratio is high, food and cash crop production often cannot be interrupted for green manure production. Green manuring stumbles, moreover, on the problem that the water supply is generally too tight to allow for the additional cover-crops. These crops require an investment effort by the farmers that does not result in immediate and tangible effects.

7. The effectiveness of the fertilizer application can also be increased by optimal timing. At present, a lack of knowledge of exactly what the best time is, as well as delays in the supply of fertilizers to the farmers due to organizational problems and transport bottlenecks, often result in late application. To improve the situation, a large research effort is required, and agricultural extension services would have to inform the farmers about the results of this research. If the optimal timing coincides with a labor peak, mechanization may be needed to insure timely application of fertilizers.

II. Reduction of Energy Cost

8. Food and other agricultural products consume large quantities of energy. Most of this energy is sunlight, but modern agriculture also requires vast inputs of fossil fuels and electricity. E.g., the American farming system consumes more petroleum than any other single industry in the U.S.1/ An energy equivalent of 748 liters of gasoline is used for the production of one hectare of corn in the United States.2/ Most of this energy is represented by the nitrogenous fertilizers that are applied to the corn crop.

1/ Committee on Agriculture, House of Representatives, 92nd Congress, 1971, p. 20, as cited in: "The U.S. Fertilizer Situation and Outlook; A Report by the Task Force of the Council for Agricultural Science and Technology," January 1974, p. 10.

2/ Pimentel and others, "Food Production and the Energy Crisis," Science, 2 November 1973, p. 448.

Table 1 Approximate Energy Input into Nitrogen and Phosphate Fertilizer Production in 1971 1/

		Developed Countries	Developing Countries	Total	Total in 10^{12} Btu's	Percentage 2/
natural gas in million NM^3	total	22500	2500	25000	883	50^+
	N	22500	2500	25000		
	P	-	-	-		
naphtha in million metric tons	total	6.65	0.75	7.5	314	18^+
	N	6.65	0.75	7.5		
	P	-	-	-		
coal in million metric tons	total	6.85	0.75	7.7	194	11^+
	N	6.85	0.75	7.7		
	P	-	-	-		
fuel oil in million metric tons	total	1.7	0.20	1.9	73	4^+
	N	1.7	0.20	1.9		
	P	-	-	-		
refinery gas in 10^{12} Kcal	total	14.5	1.6	16.1	64	4^+
	N	14.5	1.6	16.1		
	P	-	-	-		
electricity in million KWH	total	9700	1400	11100	38	2
	N	6690	1070	7760		
	P	3000	320	3320		
fuel 2/ in 10^{12} Kcal	total	47	7	54	214	11
	N	14	3.4	17.4		
	P	33	3.4	17.4		
Total		-	-	-	1780	100
	N	-	-	-		
	P	-	-	-		

1/ Excluding energy consumed for production of machinery and other capital goods, rock phosphate mining and sulphur production.

2/ The input "fuel" consists of unallocated, different fuel sources used in the conversion of ammonia and phosphatic acid to end products. Part of this consists of natural gas, part of naphtha, coal, fuel oil, and refinery gas. The exact allocation is not known. This means that the percentages of the different energy sources given in the last column are minimal; the remaining 11% should be distributed among them.

Source: R.P. Cook, "Fertilizer Production in the World From 1971 to 1980," UNIDO/ITD. 218, tables 14, 16, 17 and 18.

9. Of all energy that goes into fertilizer production, about 87 percent is consumed by nitrogenous fertilizers, and only 5 percent by phosphatic fertilizers and 8 percent by potassic fertilizers.1/ The approximate amount of energy consumed by the world's fertilizer industries is shown in Table 1. Most energy sources for the production of fertilizers are fossil fuels: natural gas (over 50% of all energy consumed in fertilizer production), naphtha (over 18%), coal (over 11%), fuel oil (over 4%), refinery gas (over 4%), and electricity (approximately 2%). (The remaining 11 percent is unallocated).

10. The methods to produce fertilizers from non-petroleum products, to which Dr. Kissinger referred, include ammonia and urea production from (i) natural gas, (ii) coal, brown coal, and lignite, (iii) hydro-power, (iv) nuclear power, (v) bio-gas from garbage, manures and other organic wastes, and (vi) other potential energy sources. Each of these subjects is dealt with below.

(i) Natural Gas

11. Ammonia production clearly offers possibilities for changes to non-petroleum energy sources. Most ammonia is today already being produced from natural gas. See Table 2. Natural gas is becoming scarce and expensive in the industrialized nations; in the coming years, the cif natural gas price may move up to $1.00 - 1.50 per million Btu, parallel with the rise of crude oil. In most developing countries, however, natural gas will remain cheaper, due to the high transportation costs of gas products (liquefied gas, methanol, ammonia) to Japan, Western Europe, and the United States. Developing countries with large gas reserves in associated or unassociated form do not need to develop feedstocks other than gas and can greatly expand their ammonia industry. This applies particularly to those which flare most of their associated gas.

Table 2: Feedstocks of Ammonia, 1971

	Ammonia in million metric tons	Percentage
Natural Gas	26.4	60
Naphtha	8.7	20
Coal	4.0	9
Fuel Oil	2.0	4.5
Refinery Gas	2.0	4.5
Electrolytic Hydrogen	0.9	2
Total World	44.0	100

Source: R. P. Cook, "Fertilizer Production in the World from 1971 to 1980" UNIDO/ITD. 218 dd Oct. 3, 1973, p. 5.

1/ Task Force, Op. Cit., p. 9.

12. Natural gas is the most important, energy-efficient and cheapest raw material for nitrogenous fertilizers. In 1971, the world's natural gas reserves were estimated at least at 50 trillion (10^{12}) cubic metres.1/ Probably more than 14 trillion is located in OPEC countries. Net world production surpassed 1,142 billion (10^9)m^3 in 1971. About 49.8 billion (or 4.4 percent) was produced by the OPEC countries.2/ (Net equals gross minus re-injected, flared, vented, or otherwise wasted gas.) The potential net production of OPEC countries is many times higher. The reserves of the members would last, on average, 67 years if the gross production of 1972 would continue till depletion.

13. In 1972, more than 62 percent of all gas produced by OPEC members was flared, surpassing 130 billion m^3. This quantity of gas could be put to several good uses, one of which would be ammonia production for nitrogenous fertilizers. 130 billion m^3 would be enough to produce 83.4 million tons of ammonia.3/ In 1971/72, total ammonia production in LDC's was 5,801,000 metric tons of N (including Socialist Asia), which equals 7,074,390 metric tons of ammonia.4/ The volume of gas flared in the OPEC countries would enable them to increase the ammonia output of LDC's almost 12 times at very low costs.

14. The consumption of N-fertilizers by LDC's (excluding Socialist Asia) reached 5,890,000 metric tons of N in 1971/72, and the Bank Group Fertilizer Policy and Program projects that the demand will reach 15,475,000 metric tons in 1980/81. The amount of ammonia necessary to meet this is 18,871,951 metric tons in 1980/81. The oil companies in the OPEC countries flared enough gas in 1972 to satisfy this future demand four and a half times. (This figure puts the present and projected fertilizer shortages in the LDC's in the proper perspective of today's energy and feedstock waste.)

(ii) Coal

15. Before the Second World War, almost all ammonia was produced from coal. The investment costs of coal-based plants are much higher than those of plants using other materials. (See Table 4.) Large amounts of coal are required; maintenance and operating costs are high. Also, coal is more polluting. For these reasons, coal has fallen into disfavor, although it is more plentiful than petroleum and gas. Some developing countries have large amounts which can be mined at low cost, however.

1/ UN, Statistical Yearbook 1972, pp. 182-3.

2/ Excluding Kuwait, for which no net production figure is available. Source: OPEC, Annual Statistical Bulletin 1972, p. 11.

3/ Using 55 million scf for 1,000 metric tons of ammonia, which is a conservative estimate.

4/ Ammonia has 82% N.

Table 3: Natural Gas: Production, Utilization and Flaring, 1971 - 1972

	Reserves 1/ billion (10^9)	Production 1972 million (10^6)	Utilization 3/ 1972 million (10^6)	Flared 1972 million (10^6)	Flared as % of produced	Annually flared as % of reserves	Reserves - annual production (in years)
	(cubic meters)						
Abu Dhabi	na	11215	1038	10177	91	na	na
Algeria	4417	15529	6904	8625	56	0.2	284
Indonesia	147	na	4147	na	na	na	na
Iran	3681	41685	17757	23928	57	0.7	88
Iraq	566	7420	935	6485	87	1.1	76
Kuwait	1119	18343	6992	11351	62	1.0	61
Libya	767	14047	7813	6234	44	0.8	55
Nigeria	283	17122	273	16849	98	6.0	17
Qatar	229	5380	1103	4277	79	1.9	43
Saudi-Arabia	1918	32568	5509	27059	83	1.4	59
Venezuela	896	46020	31493	14527	32	1.6	19
Total OPEC	14023 4/	209329 5/	83964	129512 5/	62 5/	0.9 4/ 5/	67 4/ 5/
World	49900 2/	na	na	na	na	na	na

1/ Source: World Oil (Houston: Texas), as quoted in the UN Statistical Yearook, 1972, pp. 182-3.
2/ Represents the total of all countries listed in the UN Statistical Yearbook for which figures are available. Actual reserves must be much higher.
3/ Consisting of re-injection, local consumption, and export.
4/ Excl. Abu Dhabi
5/ Excl. Indonesia

Source: Direct communications to the OPEC - Secretariat. Annual Statistical Bulletin 1972, Organization of the Petroleum Exporting Countries, Statistics Unit.

India and South Africa, e.g., have already coal-based ammonia plants. The high present prices of naphtha and fuel oil, combined with the desire for increasing national self-reliance as well as awareness of a possible depletion of gas and oil reserves, are currently revitalizing the interest in coal. The Soviet Union plans to establish three coal-based plants in India, and the United States ordered recently six German coal-gasification plants which could be used for ammonia production (among other purposes). Use of domestic coal saves foreign currency if the alternative is importation of feedstocks, intermediates, or end products. It creates employment and may stimulate other industrial or domestic usages of coal, where a large customer like an ammonia plant is required to achieve a minimum mine production. The same advantages are attached to lignite and brown coal, which are cheaper, but also bulkier because of high water contents, and are therefore costly to transport.

Table 4: Approximate Investment Costs of Ammonia Plants in LDC's For completion in late 1970's. Figures in millions of constant 1973 dollars. Capacities in metric tons per day.

	Capacity	
	600 MT/D	1,000 MT/D
Feedstock:		
Natural Gas	32	44
Naphtha	35	49
Heavy Oil	41	55
Coal	58	78

Including all off-sites and storage facilities.

Source: Bank Group Fertilizer Policy and Program, Annex II, Table 6.

16. There are both well-established and new technologies for ammonia production from coal. In old processes, ammonia is made from the town gas or coke that is derived from coal. In such current processes as the Lurgi and Winkler ones, coal is gasified and ammonia is derived from syngas. A new and promising method is presently in development by Texaco. Partial oxidation of finely ground coal, in an oil slurry or simply water, replaces naphtha or fuel oil in the partial oxidation process. Partial oxidation plants using naphtha or oil could be converted to pulverized coal plants with minor alterations. In 3-5 years, this method should be ready for commercial application on a large scale, which holds a great promise for a country like India.

(iii) Hydro-Power

17. Presently, only 2% of all ammonia is produced with hydro-power or other sources of electrolytic hydrogen. In general, electricity is too expensive as compared to fossil fuels. Only where a surplus electricity capacity exists will it be economic to use power for the production of fertilizer. Fertilizer production on the basis of electricity does take place, e.g., in Peru, India, and Egypt; but in Peru the production costs are too high, and in India the plant concerned is being converted to fuel oil. One of the few developing countries which presently has an opportunity for expanded fertilizer production on the basis of hydro-power is the Philippines.1/ In general, the share of hydro-power in fertilizer production cannot be greatly expanded in an economically justifiable way.

(iv) Nuclear Power

18. Nuclear power from fusion is generally expected to become an economical energy source for wide application within a couple of years. Important safety problems have still to be solved. Nuclear power from fission, though potentially much cheaper, is still far from the stage of general applicability.

19. The electricity generated by fusion or fission can be used to produce ammonia by combining hydrogen from water electrolysis with nitrogen from the air. Phosporous fertilizers can also be produced with electricity, which would replace the sulphuric acid in the conventional process.

20. Large agro-industrial nuclear complexes have been suggested for LDCs by Edward A. Mason,2/ but at the moment this idea does not yet seem ready for implementation. In any case, the expansion of nuclear energy generation is constrained by lead times of 7-10 years. It will probably remain an insignificant source for fertilizer production till about 1985.

(v) Bio-gas and Garbage-Fuel

21. A cheap but ignored source of methane gas, which is an excellent feedstock and fuel for ammonia and urea production, is the gas produced by fermenting garbage, cellulose, manures, and other organic wastes. Biogas is a natural by-product of the decomposition of cow-dung and other wastes and is being used on a limited basis to provide fuel in some Indian villages. This process reduces loss of organic matter through decomposition, preserves the organic plant nutrients, and provides up to 2,000 cu. ft. of cooking gas per metric ton of fresh cow-dung. The potential methane

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1/ In the Mabuhay electrolysis plant, hydrogen by-product is presently being wasted. According to IFC, 37,000 metric tons of urea could be produced annually, at an investment cost of only 8 million dollars. See T. H. Liem, Office Memorandum to H. G. Hilton, dd, September 17, 1973.

2/ In: "An Analysis of Nuclear Agro-Industrial Complexes," Science and Technology in Developing Countries, edited by C. Nader and A. B. Zahlan (Cambridge: University Press, 1969).

gas production based on the number of cows in LDC's in 1971 is at least 12.3 trillion (10^{12}) cu. ft. Experiments show that gas for cooking, irrigation pumping, and village electrification can be produced with relatively simple equipment and at low investment and processing costs (See Annex I, p. 2 (footnote); 5-7, for the data on which these estimates are based).

22. The potential gas production from cow-dung alone, valued for instance at a low gas price of US$.10/1,000 cu. ft., represents a gross value of US$1.23 billion on the basis of the 1971 dung production. In addition, the remaining sludge can be used as manure, because plant nutrient losses during fermentation are minimal. The process of capturing methane gas and simultaneously producing good fertilizer is technically feasible for certain urban composts and sludges, too. At least one plant in Great Britain is operating in this manner. This points to the possibility of combining the functions of hygenic waste disposal, organic fertilizer production, methane gas production, and recycling of salvageable materials (metals) in one and the same plant.

23. Apart from bio-gas production, waste products can be used for energy generation by simply burning them. The U.S. Environmental Protection Agency has recently estimated that 70-80 percent of the 90 million tons of home and industrial garbage annually produced in the U.S. can be burned as fuel, producing the equivalent of 150 million barrels of oil a year. As the garbage production per capita is considerably lower in LDC's, large garbage-fuel plants are not as widely applicable as in the U.S. Much waste and manure is already being burnt in LDC's for cooking purposes. The energy efficiency of household burning is low, however. If the manures and cellulosic wastes were used for methane gas production in village bio-gas plants, the net energy gain would be higher. In addition, the remaining sludge could be used as fertilizer.

24. In theory, all "alternative" energy sources can be used for fertilizer production. Shale oil and sand tar are not projected to become significant supply sources in the near future, because of technological problems, a long lead lime, high manufacturing costs, and other problems. No proposals are known for fertilizer production based on solar or geothermal energy. NASA's idea to generate electricity and produce liquid hydrogen in huge underwater plants in the Mexican Gulf may only be realized in the distant future.

III. Organic Plant Nutrients

25. Traditional agriculture has generally relied exclusively for its nutrient requirements on (i) manures and other decomposing organic materials, (ii) atmospheric nitrogen fixation by lightning and radiation, and (iii) nitrogen fixation by soil bacteria and other organisms. It does not seem

possible or advisable to manipulate atmospheric nitrogen fixation, but organic waste products and biological nitrogen fixation are much more important potential sources for the development of agriculture in an ecologically sound and energy-economic fashion than is generally understood. Both subjects are dealt with below.

(i) Biological Nitrogen

26. The largest nitrogen "industry" in the world is of a bacterial nature, and is located in the surface soil of the earth. Azotobacter and Rhizobia fix about 170 million metric tons of nitrogen per year.1/ For comparison, the world's industrial production of nitrogenous fertilizers reached 33 million tons of N in 1970/71. Another 10 million metric tons of nitrogen is supplied each year to the soil by the chemical effects of lightning and ultra-violet radiation, which create nitrogen compounds in the atmosphere that enter the soil dissolved in rainwater.

27. Nitrogen-fixing organisms can be divided into two main groups: those which have symbiotic (interdependent) relationships with plants and animals, and those which live independently. Free-living organisms are the aerobic (oxygen-consuming) bacteria Azotobacter, the anaerobic bacteria Chromatium, the facultative Klebsiella (adaptable both to aerobic and anaerobic environments), and blue-green algae. Symbiotic organisms are the lichens (fungi and algae) Nostoc, the leaf nodule Klebsiella, the root nodule bacteria Rhizobia (on legumes) and Actinomyces (on other plants), certain wood and fungus Bacillus, and again the Klebsiella living on animal tissues.2/

28. The Rhizobia invade the root systems of leguminous crops and live in symbiosis with these plants by transforming atmospheric nitrogen into nitrogen compounds that can be absorbed by the plant. Examples of leguminous crops are soy beans, peanuts, chick peas, string-type beans, cow peas, and pigeon peas. The fact that these crops are so high in protein, while they require little or no nitrogen fertilizer, is entirely due to the symbiosis with Rhizobia.

29. The Azotobacter are free-living bacteria which are present in most soils. Some of these free-living bacteria develop particularly in association with certain plants. Rice, sorghum, millet, some tropical grasses, and to a lesser extent, maize have been shown to benefit from the nitrogen-fixing activity of Azotobacter.

30. Blue-green algae fix nitrogen on the crust of the soil surface in humid conditions and are known to have a beneficial effect on rice yields. The age-old, continuous wet rice cultivation in many Southeast Asian countries has been possible partly because of this natural fixation by blue-green algae.

1/ Ralph Hardy, as quoted in the Wall Street Journal, February 7, 1974, p. 1.

2/ "Protein from Air," Mosaic, IV (No. 4, Fall 1973), p. 24.

31. Shifting cultivation traditionally relies almost exclusively on naturally fixed nitrogen. Several tropical plants accumulate nitrogen during the fallow period. It is also known that certain trees, such as the elm tree, have symbiotic relationships with nitrogen fixing bacteria. Bacterial nitrogen fixation even occurs in the intestines of animals and human beings, thus enabling them to subsist on minimal amounts of protein. Very little nitrogen fixation has been found so far to occur in wheat crops.

32. The amounts of fixed nitrogen can reach substantial levels: it has been found that grassland mixed with legumes can fix about 200 kilograms of nitrogen per ha annually. It is probable that the quantities of nitrogen fixed in tropical soils can be very high under certain conditions. There is a wide range of leguminous plants which can be used in tropical agriculture for green manure or fodder.

33. The factors that influence biological nitrogen fixation are: (1) temperature (high temperatures stimulate fixation); (2) light intensity and day length; (3) soil humidity; (4) soil tillage and physical structure (one of the reasons why very little nitrogen fixation occurs in wheat may be that the soil is too open; too much oxygen inhibits the activity of the bacteria concerned); (5) the acidity of the soil (pH); (6) the amount and type of organic matter in the soil; (7) presence of phosphates (phosphorus increases notrogen fixation);1/ (8) presence of the proper kind of bacteria. Many different Rhizobia strains exist; they are very selective and work only in symbiosis with certain crop varieties. It is therefore necessary to inoculate the seeds of leguminous crops with the proper strains of Rhizobia. One method is to grind peat mixed with bacteria and add this to the seed. (This method does not work in dry conditions.) Another method is to use brown coal with which pellets of seed and bacteria are made. In acid soils, lime pelletting of seeds can be successful; the lime neutralizes the acidity and creates a micro-environment around the seed that is favorable to the bacteria.

34. Large amounts of chemical fertilizers impede biological nitrogen fixation. Although an initial dressing of about 20 lbs of nitrogen per acre may help a soy crop to develop its root system, thus stimulating the formation of nodules, additional amounts of chemical nitrogen gradually reduce bacterial fixation to nought. Therefore, the application of moderate or large quantities of nitrogenous fertilizer on leguminous crops is economically wasteful.2/

35. The problems of greater usage of biological nitrate fixation are that too little is known about the bacteria, the symbiosis, and the association with non-leguminous crops. Only a limited number of scientific researchers is working on this matter, mainly in the USA, Australia, and Great Britain. It is first of all necessary to greatly expand research

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1/ It has recently been found, too, that certain soil fungi can infect the root system of crops and produce a mantle of fungus and assists the roots in the dissolution of phosphatic salts.

2/ C. R. Weber, "Status of Soybean Nodules," Plant Food Review, Winter 1966, pp. 14-15.

in the tropics and to go into inoculant production. After more information has been gathered, training of researchers and extension officers will be necessary in the various developing countries. As biological nitrogen fixation varies greatly among soils, crops, and climates, future extension activities should be based on local findings. If the funds devoted to these matters would be increased greatly (presently, less than half a million dollars goes into this matter annually), it could be expected that, within a few years, important research results would be ready for farm application.

36. There are various avenues to a greater utilization of biological nitrogen fixation: (i) manipulation of Rhizobia genes in order to duplicate the symbiosis with leguminous crops on non-leguminous crops, particularly cereals; (ii) the nitrogen producing mechanism of the various bacteria might be installed into plant cells by manipulating the genetic base of plants in order to allow them to produce protein from atmospheric nitrogen themselves; and (iii) it may prove possible to mimic the nitrogen fixation mechanism in an industrial fashion. Certain enzymes (nitrogenase) and catalytic metals could be used in the production of nitrogen from the air. It may be possible to apply this in farm-based units that would draw nitrogen from the air and convert it to ammonia. Such a system, while probably using some electricity, might greatly reduce the amount of energy required for the production of nitrogen fertilizer, and eliminate the need for import of fertilizers and transportation of fertilizers over long distances.

(ii) Fertilization with Waste Products

37. Organic fertilization with waste products is generally associated with "organic agriculture," which is often seen as a luxury concern of well-fed idealists in industrial countries. The subject deserves more serious consideration, however, and is more potentially important for developing countries than is often realized. The current exorbitant fertilizer prices, the energy crisis, foreign exchange shortages, and soil erosion in developing countries are factors that justify more attention for organic manures.

38. As estimated in Annex I, the total production in LDC's of soil nutrients (N, P and K) in organic wastes that can theoretically be used in agriculture was approximately 7.8 times larger than the consumption of chemical fertilizers by LDC's in 1971. A very significant contribution to food production growth, soil conservation, sanitary and ecological objectives, energy conservation, and foreign exchange savings would be achieved if rural and urban wastes would be better utilized.

39. The value of the plant nutrients in the potential production of organic manures in the LDC's is estimated at over 16 billion dollars. (See Annex I). Most of this is wasted by dumping and incineration. In addition, organic wastes can be used to produce methane gas, without losing their value as fertilizers. As indicated in paragraphs 19 and 20, cow-dung alone has a potential of about 12 trillion cubic feet of methane per year, which represents a value of at least 1 billion dollars.

40. It is true, part of these fertilizer and energy potentials cannot be captured for technical or economic reasons. But with a few exceptions, most nations neglect these potentials and do not engage in substantial research to lower costs and improve gas and nutrient recovery.

41. Judged by the standards of conventional economic analysis, composting and gasification may remain economically not very attractive even after technical improvements. However, the non-monetary values of hygienic waste-disposal, pollution control, soil conservation (and the better utilization of chemical fertilizers achieved by organic manure application) would justify government support for composting and sewage irrigation on a large scale. These are matters of collective and long-term interests that should not be left to the free market mechanism.

42. Fertilization with waste products may gradually become more attractive by sheer economic and technical necessity: the costs of pollution and erosion rise rapidly, and supply of wastes increases steadily with the growth of world population. Potash and phosphorus resources are limited; their gradual depletion will eventually make recycling of wastes imperative. Nitrogen is non-depletable, though the energy needed for the production of nitrogenous fertilizers also requires more attention for recycling.

43. It is recommended that national governments and foreign aid donors devote more attention to this matter through research as well as technical and financial assistance. The following two tasks could be given to a new Plant Nutrient Institute, or can be executed by existing institutions. They involve little manpower and can be executed at low cost by research-assistants or junior officials:

(1) An inventory study of the existing experience and research results concerning composting, sewage irrigation, bio-gas production, and ecologically responsible waste disposal in both rich and poor countries. This study should focus not only on the financial, but also on the social costs involved in the different ways of waste disposal and waste utilization, especially in overpopulated regions with high unemployment and low labor cost. The proposed study would require about 4-6 man-months.

(2) If the findings of this inventory study warrant further action (which is likely), it could be proposed to FAO, WHO, UNIDO, and the UN Environment Program to jointly issue a manual on waste disposal and organic fertilization in less developed countries. This manual could be written by about 8 experts and would require one editor. Total costs of the manual are estimated at 12 man-months, plus publishing costs of about $6,000.

IV. Conclusion

44. The establishment of an International Plant Nutrition Institute as a new agency that expands and coordinates the work of the various existing research institutions can make a significant contribution to world food production in the future. Production of fertilizer from non-petroleum sources (natural gas, coal, etc.) is already under way and can be greatly expanded by the end of the 1970's. Use of gas that is presently flared is the most promising possibility, but the construction of additional plant capacity in LDC's requires 4-5 years. In the meantime, upgrading of existing fertilizer plants in LDC's to increase capacity utilization, and import of fertilizers from the Communist and OECD countries at reasonable costs, are the only means to increase fertilizer consumption in the LDC's.

45. The potentials of alternative energy sources like nuclear energy, bio-gas, garbage power, sand tar, shale oil, etc., are promising, but need further research. These sources cannot be expected to contribute significantly to fertilizer production before the mid-1980's.

46. The potential production of plant nutrients by biological fixation and utilization of organic wastes is very great, but here, too, a major research effort, as well as a reorientation of agricultural thinking and an enormous organizational and extension effort are required. A significant impact of organic fertilization cannot be expected before the end of the present decade.

JCVoorhoeve:nw

Attachment

ORGANIC FERTILIZERS

PROBLEMS AND POTENTIAL FOR DEVELOPING COUNTRIES[1/]

1. Waste products from plants, animals, and humans contain plant nutrients and organic materials that are valuable to agriculture. As set forth in background study No. 4 of the Bank Group Fertilizer Policy and Program, the potential contribution of organic wastes to agricultural production is larger than is generally understood. The environmental costs of most contemporary methods of urban waste disposal (incineration, dumping onto land or into water) are very high.

2. Land, with a good crop cover, is an inexpensive and natural oxidative system for the safe disposal of the organic wastes which are left behind by most types of human, animal, and plant activity. Utilization of wastes as a means of crop fertilization has been practiced in many parts of the world for centuries. Among the most common are:

(1) Compost: The decomposition, natural or induced, of organic matter in some organized manner. The value of compost as a fertilizer depends on its composition (from agriculture: rice hulls, weeds, unused plant matter; from industry: processed food and fiber residues; other: bone-meal, fish-scrap, paper products, etc.) and the system of composting used (losses of nitrogen may easily vary from 10-60%). Farm composting efficiently combines waste disposal with soil structure amelioration and plant fertilization at low cost to the farmer. Urban composting may serve a similar purpose, but often at a higher cost, due to land and sanitation restrictions as well as the high concentration of wastes in urban areas. Mechanical composting in urban areas has the added economic benefits of the sale of salvaged metal, rags, and papers.

(2) Manures: Animal manures provide the largest single organic source of crop nutrients. Manures are readily available in rural areas, but do not contain high concentrations of N, P or K. Fresh manuring (the application of fresh manure directly to cropland) is often discouraged because of the weed seeds, worms, insect pests and other harmful organisms that may be contained

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1/ This annex is an excerpt of the Bank Group Fertilizer Policy and Program Background Paper No. 4.

in the excrement. Manures are often first rotted, a heat-producing process which destroys most of these negative aspects. An important potential of animal manures, especially cow-dung, is the production of methane gas, a natural by-product of the decomposition process.

(3) Green Manures: Green manures are plant crops which are not (or only partly) harvested, and are grown to prevent nutrient leaching, ti improve the soil structure, and to add organic matter to the soil. Leguminous green manures add significant quantities of N to the soil, as their root systems contain N-fixing bacteria.

(4) Night Soil: Night soil (human excrement) has a somewhat higher nitrogen content than animal manures and has been used with some success especially in China, India and Japan. As with animal manures, it can be applied in its raw state, but due to problems of hygiene, it should undergo the time-consuming process of decomposition before application.

(5) Urban Sewage: Urban areas often have a great but underutilized fertilizer potential in the form of sewage, which for the most part is dumped into a nearby body of water, in treated or untreated form. Sewage has two components: the solid portion, or sludge, and the liquid portion, or sewage water. In its liquid form it can be utilized in irrigation of cropland, and in its solid form it can be processed and later utilized as a good quality fertilizer. Hygiene requires that untreated forms of sewage be used only on fodder and selected food crops such as sugarcane, wheat, or fruit orchards.

The Potential for Organic Fertilizer Production in LDC's

3. It would be interesting to know how large the quantities of organic fertilizers are, and what their potential value might be. Organic fertilization is often discarded by agriculturalists and economists as a romantic idea that endears only those with no concept of the total nutrient requirements of agriculture and the costs which are involved in organic fertilization. It might be, however, that a contemporary bias, caused by the high labor costs of handling wastes in industrialized nations, and a preference for clean industrial fertilizers, as well as a gross underestimation of the long-term costs of pollution and erosion, hamper objective investigation.

4. Any effort to pull together statistics on wastes in LDC's stumbles unfortunately on the lack of research that has been carried out on this subject. Moreover, the figures that are available may not be entirely reliable. A preliminary investigation is worthwhile, however, at least to demonstrate the quantities involved. Table 1 indicates that the total availability of organic fertilizers is very large indeed.1/

1/ This table was calculated on the basis of various publications, especially Organic Manures, Indian Council of Agricultural Research, Technical Bulletin No. 32, FAO's Production Yearbook 1971, and IBRD's Trends in Developing Countries (1973). The LDC total for human excrement is based on the Indian calculation of 0.0047 metric tons N/person/yr., 0.0011 metric tons P_2O_5/per./yr., 0.0010 metric tons K/per./yr., multiplied by a total LDC population estimate for 1971 and 1980. Cattle estimates are based on Indian figures of 8.6 metric tons/cow/yr. excrement (liquid and solid) x number of LDC cattle (FAO Production Yearbook, 1971, p. 303) x the respective percentages of N, P and K of .0029, .0008 and .0023, likewise based on Indian findings. Assuming that cattle production will rise at least as rapidly as human population growth rates, the 1980 estimated cattle population was based on the human growth factor of 1.25. All other categories are based on a similar methodology, i.e. an extrapolation of Indian findings. As waste production increases sharply with income per capita and feed/animal, and extrapolation of Indian experience is bound to be a conservative estimate.

TABLE 1: Total annual production of soil nutrients (N, P, K) through organic wastes in the developing world, 1971 (actual) and 1980 (estimated)1/

(million metric tons of nutrients)

Source		N	P	K
Human:				
	1971	12.25	2.87	2.61
	1980	15.26	3.57	3.25
Cattle:				
	1971	17.80	4.91	14.12
	1980	22.25	6.14	17.65
Farm Compost:				
	1971	9.54	3.34	9.54
	1980	11.93	4.18	11.93
Urban Compost:				
	1971	.48	.38	.57
	1980	.60	.48	.71
Urban Sewage:				
	1971	1.43	.29	.86
	1980	1.79	.36	1.08
Other2/				
	1971	6.63	4.44	11.35
	1980	8.29	5.55	14.19
TOTAL:				
	1971	48.13	16.23	39.05
	1980	60.12	20.28	48.81

1/ Excludes Central America and Oceania, includes Socialist Asia.

2/ Bone-meal, poultry litter, bagasse, sheep/goat litter, oil cake, press-mud. (Several other sources were not included due to small potential for all developing world.)

These figures, of course, indicate only raw output. Whether the degree to which this potential could economically be harnessed to serve the world's agricultural needs is, e.g., 60% or 80%, is a matter of speculation. Furthermore, in the case of human excrement, animal excrement, and urban sewage, our calculations for N production could be reduced by 0-50%, depending upon the assumed method of processing. (All other categories have already been adjusted to account for N losses in normal processing.)

5. To compare the figures of Table 1, it should be noted that the actual consumption of inorganic fertilizers in LDC's during 1970/71 was 13.2 million metric tons of N, P, and K.1/ In other words, the total production in LDC's of soil nutrients in organic manures that might theoretically be used in agriculture was about 7.8 times larger than the consumption of chemical fertilizers during 1971.

6. The World Bank Group has estimated that the future nitrogenous and phosphatic fertilizer consumption will be about 30 million tons of N and P in all developing countries in 1980/81 (including Socialist Asia). In Table 1 we have estimated an indigenous potential of 64.36 million metric tons of N and P in organic forms in 1971. By 1980, yearly output should be at least 80.40 million metric tons of N and P. We would anticipate, therefore, that a very significant contribution to agricultural fertilization could be made simply through an improved utilization of rural and urban wastes. Even an increase of, say, 10% of the degree to which these wastes are now utilized would be a substantial contribution to tropical agriculture.

Economic Implications

7. The total nutrient production by wastes, and their potential value as fertilizers, demonstrates their potential as substitutes for chemical fertilizers, whose prices are skyrocketing as a result of cyclic shortages--which are compounded by the rise in energy costs. Table 2 indicates the value of the organic nutrient production at 1973 world prices (f.o.b.) of chemical fertilizers.

1/ FAO Annual Fertilizer Review 1971, p. 36, including Socialist Asia.

TABLE 2: Value of N, P, and K found in wastes of the developing world as compared to chemical fertilizers (at 1973 world f.o.b. prices)1/

(in millions of US$)

	N	P	K	Total
1971	9,626	4,058	2,499	16,183
1980	12,024	5,070	3,124	20,218

8. Economic costs of organic fertilizer production vary widely, and depend upon the processing method. We do not have sufficient data to estimate the cost of labor-intensive waste processing for fertilization. Mechanical composting costs known to us vary widely. Net production costs of a 200 long ton-per-day plant in the United States are $7.73-0.23 per long ton of processed refuse, after deduction of salvage sales. Due to a greater market for compost and a good return on salvage operations, European compost costs are a good deal lower.2/

9. An important source for defraying the costs of organic fertilizers is methane gas production. Methane gas is a natural by-product of the decomposition of cow-dung and other wastes and is being used on a limited basis to provide fuel in some Indian villages. This process reduces loss of organic matter through decomposition, stops nitrogen loss, and provides up to 2,000 cu. ft. of cooking gas per metric ton of fresh cow-dung. This converts to a potential methane gas production of 12.3 trillion (10^{12}) cu. ft. for all developing countries in 1971, and a 15.3 trillion cu. ft. potential

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1/ The individual farmer pays, of course, local prices, which are higher than world prices because of transport, storage, and commercial costs. He may also benefit from government subsidization of fertilizer costs, however. In Table 2, the value of N is based on the world f.o.b. price of urea (45% N) at US$70-105 metric ton, which means a price of $155-233 per ton of pure N. The average value was set at a median of US$200/ metric ton. P_2O_5 value is based on triple superphosphate (48% P_2O_5) at $120 metric ton which means $250 per ton of P. The K-value is based on potassium cloride (62% K) at $40/metric ton which means $64 metric ton of K.

2/ Note should be made here of IFC's unsuccessful involvement in the Aevol Industrial Co. of Organic Fertilizer, S.A. (Greece). The economic difficulties of this company were primarily due to mismanagement and not inherent in the composting operation.

for 1980.[1] Experiments show that gas for cooking, irrigation pumping, and village electrification can be produced with relatively simple equipment and at low investment and processing costs.[2]

TABLE 3: Manure obtained when one tonne of fresh dung is processed by (A) the traditional Indian methods and (B) through a gas-plant (fresh dung, 1,000 kg. at 0.25% nitrogen)

		Traditional Method	Obtained through Gas-Plant
(a)	Organic matter - loss by decomposition	-500 kg.	-270 kg.
(b)	Nitrogen - loss by decomposition	-1.25 kg.	Nil
(c)	Final manure quantity	500 kg.	730 kg.
	Quality - N% on dry basis	1.0 kg.	1.37%
(d)	Additional advantage	-	2,000 cu. ft. gas for cooking

Source: Garg, A.C. et. al Organic Manures (Indian Council of Agricultural Research, technical bulletin No. 32, 1971), p. 29.

10. The potential gas production from cow-dung alone, valued for instance at a low price of US$.10/1,000 cu. ft., represents a gross value of US$1.23 billion in 1971 and US$1.53 billion in 1980. In addition, gas can be produced from various other manures and garbage. The process of capturing methane gas and simultaneously producing good fertilizer has now become technically feasible for certain urban composts and sludges. At least one plant in Great Britain is operating in this manner. This points to the possibility of combining the functions of hygienic waste disposal, organic fertilizer production, methane gas production, and recycling of salvageable materials (metals) in one and the same plant.

1/ This figure is a conservative estimate of the theoretical potential. Research in India has shown higher quantities of bio-gas production for like amounts of cow-dung, dependent upon the material mixed with it. E.g., 300 grams of fresh dung mixed with 30 grams of cellulose produces 36 liters of bio-gas in 9 weeks. Bio-gas contains about 60% methane and 40% carbon dioxide.

2/ Benefit-cost studies will be published by A. Makhijani of the Ford Foundation's Energy Policy Project in 1974.

The Agricultural and Environmental Value of Organic Fertilizers

11. Compost and other organic fertilizers are generally considered to be most valuable as soil conditioners and not as fertilizers. As fertilizers, these wastes contain from 0.2-1.5% N, 0.01-3% P_2O_5, and 0.2-2% K, plus certain trace elements. Artificial fertilizers are available in concentrations many times these figures. As soil conditioners, organic fertilizers provide everything that may be lacking in the physical makeup of a soil. This is particularly important for the soils of many developing countries, which often are low in organic content, are either too acidic or too alkaline, and have been alternately baked by the sun and leached and eroded by heavy rains. In this respect, organic additives will help prevent erosion, retain humidity, adjust the pH (acidity or alkalinity), improve drainage, prevent crusting and cracking, and promote normal bacterial and animal life in the soil. Organic matter is essential to increasing the ion-exchange capacity of a soil; many tropical soils are deficient in this respect.

12. Organic fertilizers are most valuable when used in tandem with chemical fertilizers. Compost, manures, etc. improve the physical and chemical aspects of the soil and help maintain optimal soil conditions for sound plant growth. They provide a source of slow-release N and other nutrients, and prevent chemical fertilizer run-off or evaporation (denitrification). Therefore, organic fertilizers increase the efficiency of inorganic fertilizers, particularly in the long run.

13. Experimentation has shown that soil erosion and water run-off are inversely proportional to the amount of organic matter contained in the soil. (See Table 4.)

TABLE 4: Conservation Effect of Compost

Compost Metric Tons/ha	Total Runoff Per Plot (liters)	Eroded Soil Per Plot (kg.-dry wgt.)
0	102.5	30.26
200	58.3	21.25
400	3.9	0.15

Source: International Research Group on Refuse Disposal, Information Bulletin Nos. 13-20, 1969, p. 39.

14. Erosion is a serious problem in developing countries, especially because of the minimal depth of the top soil and the silting of irrigation ditches. Soil conservation is necessary to prevent the loss of fertile soil, the breakdown of irrigation systems, and the retention of the capacity to meet the increasing demand for food and other agricultural products.

15. In the past, most developed and developing countries have organized their waste disposal by way of low-cost and least-effort methods--primarily dumping untreated wastes on vacant land and in neighboring bodies of water, or incineration. Waste dumping leads to the breeding of flies, parasites, and various infectious agents. Wholesale diverting of sewage into large bodies of water severely limits the normal development of aquatic plant and animal life through consumption of the available oxygen (eutrophication). Incineration pollutes the atmosphere and destroys the nutrient contents of waste.

16. Proper recycling of urban and rural wastes would greatly reduce air and water pollution and limit infectious health hazards significantly.

Problems and Possible Solutions

17. Despite the great value that organic fertilizers can have for crop production in the developing nations, only certain countries have utilized the potential to some degree. Most nations, both rich and poor, neglect or reject a better use of wastes. There are several reasons that explain this situation.

(a) Lack of Acceptance by the Farmer

18. With developed countries leading the way since the mid-50's, global interest in use of organic fertilizers has waned considerably. Especially in comparison with chemical fertilizers, organic materials have fallen in disfavor in modern industrialized agriculture. They are bulkier, less easily transported, poorer in nutrients (especially N), and may be labor-intensive--depending on the processing and application methods. The lower labor costs and generally poor soil structure in developing countries wholly or partly offsets these disadvantages, however. Rural education and extension work should develop more interest in organic fertilizers. Costs and benefits to the farmer should be clearly indicated. Independent production of bio-gas for domestic use as a by-product of manuring may promote greater acceptance of organic fertilization in rural areas.

(b) Resistance in Urban Areas

19. Urban areas in India have displayed some resistance to the utilization of urban wastes. Difficulties arise out of (1) a lack of interest by the municipal authorities--resulting largely from their inability to meet composting expenses; (2) inadequate physical infrastructure for the removal of city wastes, and organizational deficiencies, plus lack of cheap transportation to areas of cultivation after processing; (3) a lack of sufficient demand for compost, etc. in large cities that have little surrounding farmland. Most of these objections center around the issue of financing; there is simply not enough domestic capital to establish efficient disposal schemes. Foreign donors of financial or technical aid seldom show any interest in the subject of waste disposal.

(c) Public Health Problems

20. Working with wastes can lead to a series of health problems: fly and rat breeding, certain diseases, parasites, and noxious odors. Untreated wastes are in particular a great health hazard, to the extent that they are uncontrolled and unsterilized. Composting is one effective way of reducing the problem. Fly breeding can be controlled in compost by systematic turning of the compost in the 6th and 12th weeks of decomposition. Odors, rats and parasite problems can be reduced by heaping wastes under controlled conditions and in areas that are removed from population centers. The Dutch experience shows that transport costs need not be a problem. Mechanical composting is sanitary, odorless, faster than conventional methods, and provides good quality compost.

(d) Economic Return

21. Based on findings in industrial countries, the economic return on organic fertilizers, especially as compared to chemical fertilizers, has been poor. Concentrated chemical fertilizers are more efficient and less expensive than their organic counterparts. Composting plants in developed countries and especially the United States have not found the necessary markets for processed compost, and have had to rely on subsidization. The rapid rise in the costs of chemical fertilizers (100-300% since 1969) is likely to increase the profitability of organic manures, particularly now that soaring energy costs are likely to further increase fertilizer prices. The ecological advantages of waste utilization for agriculture should not be forgotten, too. The need for effective pollution and waste controls have re-kindled interest in organic fertilizers. Aside from increased agricultural production, these sanitary, environmental, and soil conservation factors have to be taken into account when calculating the total economic return. A comparison with chemical fertilizers understates the true value. Important to the developing world are also the foreign exchange savings that result from a greater utilization of domestic resources which reduces the need to import chemical fertilizers.

(e) Lack of Research in LDC's

22. With the exception of India, lack of research on organic fertilizers and proper waste disposal in the developing world is the major obstacle to a better utilization of the potential. Comprehensive analysis which stresses coordinated agricultural, environmental and public health planning is needed. Cost-benefit studies should be carried out which include all benefits and costs, in order to form a better idea of the true value of organic manures. It might also be possible to reduce capital needs of composting and bio-gas plants, and generate more employment. Admittedly, this is no easy task, as various health hazards and resistance to menial work will have to be overcome, both among workers and researchers.

Discussion Draft
May 20, 1974.

M.

ISSUES RELATING TO THE FERTILIZER SITUATION

ADC/IBRD Fertilizer Seminar, Princeton,

May 23-25, 1974.

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INTRODUCTION

1. First, it should be noted that the "energy crisis" is not a major cause of the recent shortage and price effects for fertilizer, though it has exacerbated them in some degree, especially in some countries. The nature of these effects in less developed countries (LDCs) in particular are discussed later.

2. Second, there has not been a decline in annual world fertilizer production of either nitrogen, phosphate or potash at any time in the past 15 years, and presumably for much longer than that (see Table 1). Further, there are only one or two instances where production in any one country has declined.

3. Third, there is no evidence that the current very high short-run demand for fertilizer is of a self-sustaining character (or a portent of things to come) due to a "population explosion", a "green revolution" or anything else of a cataclysmic nature.

4. On the other hand, everything points to the current fertilizer deficit being primarily demand related, reinforced by a reduced rate of growth in fertilizer production capacity in the immediate past, and various constraints on the manufacturing side which have prevented a rapid supply response. A confluence of events can be traced which have determined the nature of the shift on both the demand and supply sides. These seem likely to disappear as rapidly as they appeared, though there may be some lasting effects on both the industry and agriculture.

NATURE OF THE CURRENT SITUATION

5. The full implications of the current shortage of fertilizers have yet to be reliably assessed. As yet, the patterns of future prices for

nitrogen and phosphate fertilizer are still difficult to predict with any accuracy. Similarly, the agricultural impact of the supply shortfall has yet to be evaluated in any depth. However, the nature of the prevailing fertilizer situation is now sufficiently recognizable that some analysis can be made of the direction and orders of magnitude of the related changes and of the issues that arise in relation to it.

6. The current shortage and price increases relate to all main plant nutrients - phosphates (P), potash (K) and nitrogen (N). The problem is least serious for potash since lower amounts are used in crop production, the supply short-fall is less acute (being due mainly to transportation bottlenecks), and additional supplies are coming available quickly. The problem is also less serious for phosphate in that (like potash production) it is not directly affected by the crude oil shortage, and new production capacity is under construction - and because a reduced application of phosphate to crops for a season or so will have relatively small effects on yields from most crops (phosphate is stored in the soil whereas nitrogen is readily lost to the air or leached).

7. The major concern relates to nitrogen fertilizer. It is on HYV crop responses to nitrogen that the "green revolution" is predominantly based. Consequently, constraints on supplies and increased prices have far-reaching implications for the agriculture of many developing countries, and especially for food supplies. The major sources of nitrogen are oil- or natural gas-based processes for which feedstock supplies are short. Since the same feedstocks are used in the production of many crop protection chemicals, the problem is compounded - such inputs being also a feature of modern crop production technology.

Demand Related Effects

8. Since the demand for fertilizer is a derived demand, it is to be expected that a major shift of the kind we have experienced will be underlain by changes in the demand for crop products, especially cereals. Several factors have influenced this change. First, there is a long-term upward trend caused by (i) growing population, (ii) increases in incomes, and (iii) changes in consumption patterns.

9. The growth in population is the most stable factor affecting the increased growth in demand for food, especially cereals. This is presumably causing an overall increase in aggregate demand for food of some two percent per year, although in some countries it is greater and in others smaller due to differences in rates of population growth. Significantly, the higher rates of growth are in countries that are fertilizer deficient, and hence importers (mainly LDCs). The demand from this source is reinforced by the fact that the HYV technology, which is the primary means of increasing domestic food supplies in the LDCs, is highly fertilizer dependent.

10. Added to this is the increase in demand for food associated with the growth in incomes. Incomes increased substantially in many countries through the sixties, especially in the U.S., Western Europe and Japan, but also in Eastern Europe and some other countries. Although the direct effects of rising incomes on food prices are usually small, due to the relatively low income-elasticity of demand for food, there was perhaps some small increase in demand due to income effects.

11. The exception to the low income-elasticity for food argument occurs when people trade-up to superior goods, especially increasing their consumption of meat. This shift can cause a disproportionate increase in the demand for

grains - one pound of meat requires some four pounds of grain to produce. Although meat consumption has grown only some 2-3 percent annually over recent years, a fairly small rate of expansion, this has added to the demand for foodgrains.

12. Despite the steady upward pressure on fertilizer demand from this long-term trend there is nothing here to explain the recent surge in demand. However, there have been a series of abnormal effects on the demand for and production of foodgrains including: (i) a run-down of world grain stocks, (ii) widespread crop failures, (iii) sudden changes in the patterns of trade in foodgrains, and (iv) a sudden acreage expansion encouraged by government action in the major grain exporting countries.

13. A seemingly deliberate run-down in world stocks of foodgrains, mostly held in Western countries, is perhaps the most significant factor underlying the current situation. The acreage of wheat grown in the U.S. in 1970 was 80 percent of that in 1968 and 74 percent of the 1967 acreage, and the lowest since 1948 (see Table 2). In the U.S. some 60 million acres of cropland were held out of production through 1970-72 - nearly 20 percent of the total arable area. Similarly, due to acreage restrictions, Canada's wheat acreage in 1970 was only half the 1969 acreage and Australia's acreage was cut to 60 percent of its 1968 acreage. The effect of these acreage constraints was to cut the level of stocks held in those countries substantially.

14. Reinforcing this shift, there were widespread crop failures in 1972 which resulted in many countries, notably India and other Asian countries, importing more foodgrains than they would otherwise have done. As a consequence there was a severe shortage of wheat in 1972, to the extent that the FAO reported stocks at the end of 1972 to be at "dangerously low levels".

15. On top of this, the USSR entered the market in early 1973, buying 12 million tons of wheat from the U.S. alone. This turned the tight supply situation into a severe shortage.

16. Somewhat belatedly, in response to this not entirely unforseeable situation, the major exporting countries in 1973 raised quotas, released "set-aside" land and encouraged widespread cereal planting. Acreages in the main exporting countries rose by more than 10 percent in 1973 and are expected to be up by a similar proportion in 1974. The demand for fertilizer expanded equally suddenly.

17. Further, since fertilizer is also used on non-cereal crops, there are derived demand effects relating to changes in their production. In this category there were also several influences: (i) an upsurge in demand for industrial crops, (ii) a steep rise in the price of soybean, and (iii) diversion of some urea to livestock feed.

18. The economic resurgence in all Western countries that caused an increased demand and resulting higher prices for all basic commodities, also caused an increase in demand for industrial crops. The prices of oilcrops, coarse fibres, cotton and rubber, all increased in the early 1970s, some by fantastic amounts (see Table 3).

19. This was accompanied in 1973 by the sudden disappearance of the already depleted stock of anchovy off the coast of Peru - the major source of fishmeal used in livestock feeds. This had two effects. First, there was a significant demand increase for soybean meal as an alternative, and prices rose fourfold encouraging extra planting. Second, urea (otherwise used for fertilizer) was used as a protein substitute in feedmixes. Thus,

this capricious event caused a double demand effect on the fertilizer industry. (The anchovy have since returned - at least for the time being!)

Supply Related Effects

20. The supply of fertilizer has not been subject to variations of the same magnitude as demand. However, it has still been subject to a series of interacting events which have resulted in both a slower rate of output growth in some recent years (see Table 1) and (perhaps more importantly) in a number of constraints upon the ability of the industry to respond quickly to the changing demand situation. These events were related to the changing structure of the industry, economic and policy changes, distribution effects, and some other fortuitous events.

21. The supply situation has been influenced by some fairly significant structural changes (as discussed elsewhere, see "Fertilizer Requirements of Developing Countries"). These include: (i) a changing pattern of ownership, especially in the U.S., (ii) changing technology and scale advantages leading to larger plants, (iii) the disposal of inefficient plants, and (iv) some changes in the location of manufacture.

22. The changing pattern of ownership was largely a response by oil and gas firms who sought an outlet for their gas supplies through fertilizer. Some of these bought existing manufacturers but in most cases they started from scratch (or expanded) by building new plants. The emergence of these new large suppliers contributed to the surplus situation in the second part of the sixties. At the end of the sixties many of these plants were sold off to agricultural cooperatives and established fertilizer companies, though

some remained in the hands of oil and gas corporations. It is possible that such firms found profitable alternative uses for their feedstocks in recent times.

23. Some major changes in processing technology in the sixties lead to a new generation of fertilizer plants where there were considerable economies of scale. This lead to some of the 60-odd manufacturers in the U.S. becoming giants in the field. It also meant that there was a considerable increase in the "lumpiness" of capital investment in production capacity. This may be a significant determinant of the investment cycle characteristics in the future.

24. This modern plant made smaller plants of an earlier vintage relatively expensive to run, and lead to their early retirement when the market proved inadequate to maintain them profitably - no doubt to the chagrin of managers in 1973-74.

25. With the installation of new plants there was some shift in location within the U.S. and Europe, away from the former coal and steel centers toward the ports and fuel sources. In a global context there was also some growth of production capacity in LDCs - both in the oil and gas producing countries (e.g., Venezuela and Persian Gulf) and in the consuming countries (e.g., India).

26. While it is difficult to see how these adjustments could have contributed to a supply deficit in any major way, it is perhaps important that they caused a dynamic situation of change and uncertainty within the manufacturing industry which made rapid adjustment to the sudden expansion

of demand even more difficult than it was otherwise. Such a volatile situation almost certainly added to the degree of imperfect knowledge surrounding the planning and investment process.

27. Related to these structural adjustments within the industry, is an established cycle of investment in production capacity which has recurred irregularly since World War II. All evidence suggests that the recent resurgence in demand coincided with a low point in the swing of this cycle. Thus there was a delay in the supply response till new plant came on stream, and new investment was implemented. As this happened there were some inevitable teething troubles and the industry found itself with a greater demand than it could satisfy - at least in the short-run.

28. Reinforcing the structural and cyclical effects there were also many operational constraints, arising from: (i) the "energy crisis", (ii) environmental control regulations, (iii) world-wide shortages of basic raw materials and commodities, (iv) the shipping shortage, and (v) low plant capacity utilization, for various reasons.

29. The "energy crisis" contributed to some extent, especially in providing alternative demands for feedstocks and in delaying the supply of other inputs. The shortage of feedstocks is known to have lead to the closure of some plants in the LDCs and to reduced output from some plants in Japan. But it also clearly restricted any rapid expansion of output in many other situations.

30. Although the production capacity rating of most plants is fairly nominal, the introduction of environmental protection regulations caused some of the upper bounds on capacity utilization to be more constraining

than usual. Most plants in most countries have to conform to controls on emissions and on water heating. These also restricted an output response to higher prices.

31. Along with other industries, the fertilizer industry encountered a shortage of basic inputs, and delays in new plant deliveries, caused by scarcities associated with the concurrent peaking of the major Western economies. This not only drove up the price of basic commodities but caused shortages of steel and other metals. It also contributed in large measure to a world-wide shortage of shipping capacity - this affected both the delivery of rock phosphate and the distribution of finished fertilizers to importing countries.

32. Added to all of these factors was the low level of capacity utilization achieved in many plants. In some cases this was of an acute nature, due to teething problems in the initial operation of new plant, to the non-availability of spares and replacements, or other delays in deliveries. In other cases this problem was more chronic in character, especially in the LDCs where the level of capacity utilization is frequently around 50 percent. This is due to many factors, including poor layout, inadequate ancillary services such as power and transport, limited storage capacity, poor maintenance standards, and various bottlenecks in the logistics of the production process. Regardless of their exact nature, such capacity utilization constraints stubbornly resist short-run increases in output whatever the demand situation.

33. There was also a group of problems on the marketing and distribution side of fertilizer supply. These related to: (i) transportation, (ii) storage and stock levels, (iii) regional allocations and (iv) hoarding.

34. In addition to the shortage of international shipping tonnage, there was also a shortage of transport capacity within many countries. Rail cars were short in the U.S. and Canada - this affected both the distribution of finished fertilizer and the delivery of potash from Canada to both North American and overseas markets. India suffered a dislocation of rail services due to labor disputes and mechanical problems. The Philippines was short of coastal shipping. Many countries had similar problems which made shortages in supply even more difficult.

35. Stocks of fertilizers were very low in some countries and in many regions within countries. This was due to inadequate storage capacity in some situations, especially in areas where the HYVs were only recently introduced. In other places it followed from the need to replant crops following the poor seasons of 1972. The shortage of local stocks reinforced the supply deficiency from major distribution centers, at least in certain regions.

36. The uneven impact of the shortage was made worse by a lack of coordination in the allocation of scarce supplies, notably in the U.S.. Where several companies served one area there were cases of local surpluses and high stock levels while other localities had short supplies. The extent to which the problem was unexpected is reflected in the lack of contingency plans for this kind of allocation, and for handling many other related difficulties.

37. In addition, there was a tendency toward speculation in stocks of fertilizer. Clearly, with visibly rising prices it was profitable for

merchants at retail and wholesale levels to hold stocks for as long as possible. There are reports that such hoarding reached significant proportions in some countries. In Western countries farmers are reported to have held higher stocks than usual, probably caused by over-ordering in an uncertain supply situation.

38. Finally, there were a series of changes which especially affected supplies of fertilizer to the LDCs, including: (i) a cut-back in supplies of aid-financed fertilizer from the U.S., (ii) the removal of price controls on fertilizer in the domestic market, and (iii) the disappearance of cheap by-products usually available from Japan.

39. In 1968 USAID spent $175 million on fertilizers for export to the LDCs, in 1971 it was less than $50 million and this year is less still. This policy change has significantly influenced supplies available to some LDCs, especially Bangladesh.

40. The price of fertilizer in the U.S. was subjected to the price control regulations instituted in 1971. Subsequent to that exports rose as the relative profitability of the export market increased. When the price constraints were removed in 1973 the rate of exports subsided as all production was diverted to the domestic market.

41. In recent years, too, there has been a technological breakthrough in the production of caprolactam in Japan. This reduced the amount of ammonium sulfate as a by-product by about half. This source of supply had been regularly drawn on by India, and has proved difficult to replace.

42. In summary, the current fertilizer supply deficit has been influenced by a confluence of events, some of which are indicated above. While listing

the active ingredients in this way does not explain the situation or resolve it, it does permit some hypotheses as to the nature of the effects and thus some insight into the related issues.

IMPLICATIONS FOR AGRICULTURE

43. That the chemical fertilizer industry is but an area of a technically advanced agriculture is frequently lost sight of. The industry exists, after all, solely because we need it as an input source in the production of food and fibre. Accordingly, the agricultural implications of the current fertilizer shortage are perhaps its most significant elements. Yet there has been little discussion of this aspect.

44. World fertilizer consumption more than doubled in the ten years to 1972, reaching almost 80 million tons (see Table 1). Usage in the LDCs grew at a lower rate than in developed countries despite the demands of the "green revolution". The LDCs consumed 14 percent of total consumption in 1972, but this is projected to rise to 26 percent by 1980. The significance of fertilizer supplies to the LDCs is reflected in the estimate that 35 to 40 percent of the incremental growth rate of agricultural output is attributable to fertilizers. With a five percent shortage of fertilizer supplies food grain production in India, for instance, could fall by more than one million tons per year. This implies substantial price increases for food (which are already evident) and higher food grain imports.

45. These effects will be accompanied by major dislocations at the farm level. For those farms which are mechanized and irrigated there will be the double effect of fuel and power price increases in addition to those for fertilizer. However, more serious might be the supply availability problem,

since this could limit irrigation and cultivation to restricted areas of crops, and lead to the use of HYVs without fertilizer, in which case they may yield less than traditional varieties. Less mechanized farms and those in rainfed areas are likely to be less seriously affected since they use less fuel and fertilizer in the first place.

Effects on Farm Costs

46. Current indications are that farmers face a threefold increase in the price for fertilizer within the year 1973/74 (see Table 3). Fertilizer and other chemicals costs ranged from zero to 40 percent of total farm costs depending on the production situation. This means that, in general, farm operating costs could rise in the short-run from zero for subsistence smallholders to as much as 100 percent for those using modern technology.

47. Clearly, the actual increase in costs will vary, first, with the level of fertilizer inputs used. Irrigated farms growing HYVs (such as those in the Punjab) are likely to be the most severely affected. The cost impact will not, however, be direct and simple, since farmers will respond to the price increases by various shifts in production patterns - changing to crops and varieties with lower fertilizer needs, using lower fertilizer dressings and substituting other inputs for fertilizer (such as green manuring). In this way the full impact of increased costs will be offset, but some loss of income may also be incurred depending on changes in product prices.

Effects on Farm Product Prices

48. Consequent upon the changes in production patterns and the related reduction in output, an increase in price for farm produce is inevitable. In

fact, as with fertilizers and most basic raw materials, there has already been a substantial increase in the past year. Price indices for major farm products on the world market are shown in Table 3. The forecast prices presented here are probably little better than a guided guess at best since they take no explicit account of the expected changes in the supply of nitrogen, and are - as always - subject to unexpected changes due to seasonal conditions.

49. A crop failure in the coming season in a country such as India, when coupled with the fertilizer and fuel supply problems, could lead to massive food shortages and further price increases. On the other hand, the increased acreage of crops being grown in the food exporting nations could offset the upward pressure on food prices on the world market. Nevertheless, the impact on consumers is likely to be great, as suggested by the figures in Table 3. Given that food is their major item of expenditure, the urban poor will undoubtedly be the most severely affected.

50. On a priori grounds, the market price for cotton, coarse fibres and rubber is also likely to rise. However, cotton acreage may decline and output be reduced in response to the fertilizer and chemical price effects, though jute, sisal and rubber will feel little effect in this regard. Since all fibres and rubber have synthetic substitutes derived from petro-chemicals for which future prices will rise, however, it is therefore expected that the price for these natural products will rise. The prospects for rubber are complicated by possible changes in the motor industry in Western countries; a reduced mileage will reduce tyre replacements, smaller cars use small tyres and less rubber. However, it is predicted that as the price of isomer

rubber rises with the higher price for feedstocks, that of natural rubber will follow it. All fibres including cotton, wool, sisal and jute are expected to respond similarly at least to some extent - though for cotton the substitution possibilities may be greater than the others (in both production and end use) and the price rise correspondingly more sustained.

Effects on Output and Income

51. The direct effects on output will be a consequence of lower yields due to less fertilizer being applied. However, more complex shifts from existing cropping patterns to new ones will alter both the physical mix and the value of output. Generally, acreages of leguminous crops (such as beans, peas and gram) will not be cut back and may even expand. Other basic food crops, especially the one which is the traditional food crop in each area, will probably not decline either - if for no other reason than that they are needed for family subsistence, but also because food crop products will have increased in price substantially in the short-run unless held down by administered pricing. Acreages of basic food crops may even increase at the expense of fibre crops such as cotton, and other export crops.

52. Fertilizer will tend to be used, first, on the highest return crops (such as sugar in India and Pakistan) and second, on those with the lowest price elasticity of demand, since prices will rise most for these products. Where less fertilizer is used output can be expected to decline. In some cases there may be a switch back to traditional varieties that are less responsive to fertilizer. There may also be a switch away from high protein crops since, unless they are legumes, their fertilizer needs are higher than

other crops. Further changes, some of which may be contrary to these expectations, will be made in response to price movements for farm products, which will depend in turn on their relative scarcity and price elasticity of demand.

53. The most significant physical output effect could be in response to changes in the use of crop protection chemicals. While yields will decline more or less proportionally to the amounts of fertilizer used, the omitting of a disease spraying or use of a greater dilution of active ingredient than is advisable, could lead to an infestation which might virtually wipe out a crop. Failure to use appropriate sprayings by some farmers may have equally serious effects even for their neighbours who do. A shortage of such chemicals, or higher prices, since they have a relatively high elasticity of demand, could therefore have effects on output and incomes of much greater proportions than a comparable situation for fertilizers.

54. It is notable, however, that these effects are likely to be short lived - though they may be recurring. The very high commodity prices of past months have already begun to decline as the prospect of rebuilding foodgrain stocks becomes recognized and other shortages become less critical. Given the rate at which new fertilizer capacity is being established (5 to 6 million tons of additional nitrogen capacity is believed assured to come on stream in the U.S. within the next 12 months) severe shortages are likely to disappear quickly and prices to come down sharply (though they will probably be higher than in the past due to higher production costs). This does not reduce the seriousness of the short-run impact, especially in LDCs and particularly in South Asia.

KEY ISSUES RELATING TO FERTILIZER

55. The first issue must be the existing information state we find ourselves in regarding the factors affecting fertilizer supply and demand. Despite the heavy reliance we are putting our fertilizer supplies in terms of increased food production, we know very little about the prevailing situation, especially concerning investment plans, capacity being installed, existing capacity, levels of utilization or constraints on output within the industry. At this stage there exists no comprehensive independent reporting system; most analysts are dependent on journal reports and ad hoc information collection.

56. Even with existing resources, spread around various institutions, it would seem possible to survey all firms producing fertilizers in the world given a small amount of planning and coordination and a small travel budget. It is of some concern that the prevailing fertilizer situation should have been subject to so many desk studies with so little effort expended on fact finding - "never have so many depended on so little!". How can a better information system be organized?

57. The second issue involves what might be done to augment fertilizer supplies in the short-run. Although the critical fertilizer situation might be resolved relatively quickly, in the next year or two the effects are likely to be severe, especially in fertilizer importing countries such as India, Pakistan and Bangladesh.

58. A review of possible measures that might be adopted suggests that the scope for affecting short-run supplies is fairly limited. Some of the

possible areas for action include: (i) making better use of the amounts of fertilizer held at various points "in the pipeline - some 20 percent of annual consumption is tied up in this way in many countries, and for some it is much higher; and (ii) raising capacity utilization by removing operating constraints (debottlenecking) - an increase of 10-20 percent is suggested as feasible for Indian plants within two years. What else can be done?

59. The third issue concerns how far we can go using chemical fertilizers as a land augmenting input, in order to increase food supplies. In part this is an empirical question which can be answered in terms of finite fossil fuel reserves, but it involves much more complex issues of likely competing uses for feedstocks and possible further discoveries of reserves.

60. But, it also involves other questions. For instance, fertilizer is a bulky input which necessitates substantial investments in storage, handling and transport facilities, all of which are lacking in the LDCs. Recently the Philippines Government found that half of all their coastal shipping was tied up for several months in transporting fertilizers, even though levels of use are less than two kilograms perhectare. Are there not severe restraints on how far and how fast we can go with this type of technology, apart from the rate of adoption?

61. The fourth issue follows from the last, and concerns the possibility of developing alternative sources of nutrients. Research on soil fertility has been heavily oriented toward the use of chemical fertilizers. Even plant breeders are oriented to the promotion of a monocultural production based on chemical fertilizers.

62. There is some evidence, however, that research on biological nitrogen fixation might lead to a clear alternative to chemical inputs. There is the existing experience with the symbiotic Rhyobium in legumes which was developed as a cheap nitrogen source for a low cost agriculture. Recent studies suggest that bacteria in free association with plants, in the root zone, may be equally effective. A technological breakthrough at the research level has paved the way for substantial developments in this field. Can we divert research funds to this new priority area?

63. Finally, perhaps only after we have considered these issues can we explore the <u>likely demand for chemical fertilizers</u> in the future. Clearly we need reliable projections of demand in order to be able to organize supplies. But both supply and demand can be moulded by changes in technology and alternative means of production. So many of the underlying factors are subject to independent decisions - often in an institutional setting - that neither demand nor supply can easily be forecast. Are there ways of improving the planning process?

FERTILIZER RELATED ISSUES

A great variety of issues have been raised, by various people, as a consequence of recent experience with fertilizer supply and demand effects, some of which are summarized below. This list, despits its length, is by no means exhaustive. Clearly, too, not all of these questions are of equal importance, and certainly they cannot all be translated into feasible instruments for policy makers. This listing is presented partly as a checklist of issues, but also to indicate the extent of our lack of knowledge about an aspect of the agricultural production system upon which we are placing very heavy reliance in terms of increasing food supplies.

(a) Short-Run Adjustments

(i) Can we increase fertilizer availability in the short-run? Can intermediate stocks be reduced? Can capacity utilization be quickly increased? Do adequate incentives exist for manufacturers? Should priority be given to fertilizers in the allocation of feedstocks, energy and transport?

(ii) Can we offset shortages at the farm level? Allocations to foodcrops versus industrial crops? Reduce levels of application on all crops, whole area, or selectively? Allocations to particular regions (eg., irrigation)?

(iii) Is administrative intervention required, or should current arrangements be modified? Do cheap food policies discourage fertilizer use at higher prices? Do high tariffs on fertilizer, feedstock imports aggravate farm cost situation?

(iv) What are the returns to fertilizer use in LDCs compared to Western countries? What are the opportunity costs of fertilizing American lawns, English roses and French asparagus?

(b) Longer Run Strategies

(i) Can we rely on expanded use of chemical fertilizers to provide increased food supplies? How far (and for how long) can we go in relation to feedstocks, transport systems?

(ii) Can we rely on farming system dependent on chemical fertilizers for reliable food supplies? Risk of recurrent cycles? Dangers in possible coincidence of seasonal and industrial cycles?

(iii) Is it possible to offset cyclical movements in fertilizer prices and guard against a recurrence of crisis proportions? By what means?

(iv) Should the LDCs rely on imports or pursue self-sufficiency in the interests of conserving foreign exchange and ensuring reliable supplies?

(v) Will the LDCs be prepared to rely on imports given their recent experiences?

(vi) How did we come to be so dependent on a monocultural form of crop production based on an industrial input? Are there biases in research? Are there feasible alternatives which warrant research?

(c) Fertilizer Production

(i) Should additional capacity be located in developed countries, near feedstock sources, near to markets? What are the magnitudes of the trade-offs?

(ii) Can cheaper alternative feedstocks be found? Can flared gas be profitably used? Are there alternative means of manufacture?

(iii) Do the economies of scale of larger plants exist in LDCs? What demands do they put on logistics and management? Are there less capital-intensive means of production?

(iv) Can LDC plant capacity utilization be increased? Must it inevitably be low?

(v) What are the ancillary investments necessary to support fertilizer manufacture and distribution in LDCs? Roads? Rail? Power? Water? Shipping? Training?

(d) Agricultural Production

(i) What proportion of output is attributable to fertilizer? What is the production elasticity?

(ii) What is the response to fertilizer in terms of tons grain per ton of nutrient? Do we know enough about responses on farms, especially in the longer run? What are the production effects of a fertilizer shortage?

(iii) Since fertilizer substitutes for land in most LDCs, can we find alternative substitutions? Improved irrigation practices? Better crop husbandry (spacing, fertilizer placement, weeding)? Alternative production methods (intercropping, rotations, green manuring)?

(iv) Are there substitutes for chemical fertilizers? Unprocessed mineral sources? Usable organic materials? Biological nitrogen fixation? Microbial nutrient release?

(v) What are the ancillary costs of using chemical fertilizers (transport, storage, losses, shortages, ill-timed deliveries, field application)? What are the benefits?

(e) Information and Intervention

(i) Is better information desirable? Can it be obtained? What is the likely cost?

(ii) Is it desirable that investment in fertilizer production capacity be guided or regulated? Is this feasible?

(iii) What is the scope for international cooperation? Can it be achieved?

(iv) What is the nature of the supply response for different fertilizers in different situations?

(v) What are characteristics of the demand for different fertilizers in different countries?

(vi) To what extent is the industry oligopolistic? Have they made excess profits?

Table 1: World Fertilizer Production and Consumption - 1960-74

	NITROGEN				PHOSPHATE				POTASH			
	Production		Consumption		Production		Consumption		Production		Consumption	
	'000 tons	% change	'000 tons	% change	'000 tons P_2O_5	% change	'000 tons	% change	'000 tons K_2O	% change	'000 tons	% change
1960	11,000		10,100		10,740		10,580		9,600		9,040	
1961	12,000	9.1	11,300	11.9	11,130	3.6	10,990	3.9	9,670	0.7	9,370	3.7
1962	13,100	9.2	12,100	7.1	11,440	2.8	11,490	4.0	10,320	6.7	9,560	2.0
1963	14,500	10.7	13,700	13.2	12,200	6.6	12,190	6.1	10,820	4.8	10,230	7.0
1964	16,400	13.1	15,400	12.4	13,740	12.6	13,500	10.8	11,900	10.0	11,060	8.1
1965	18,600	13.4	17,000	10.4	15,260	11.1	14,710	9.0	13,370	12.4	12,070	9.1
1966	21,100	13.4	19,200	12.9	16,630	9.0	15,860	7.8	15,180	13.5	13,400	11.0
1967	24,700	17.1	24,000	25.0	18,780	12.9	17,780	12.1	16,000	5.4	14,310	6.8
1968	28,200	14.2	26,400	10.0	19,870	5.8	18,700	5.2	16,860	5.4	13,580	-5.1
1969	31,300	11.0	29,300	11.0	20,490	3.1	20,060	7.3	17,510	3.9	16,130	16.8
1970	33,300	6.4	31,600	7.9	21,260	3.8	20,740	3.4	18,430	5.3	17,020	5.5
1971	36,300	9.0	35,000	10.8	22,970	8.0	21,900	5.6	19,520	5.9	18,190	6.9
1972	38,700	6.6	37,200	6.3	24,810	8.0	23,250	6.2	21,210	8.7	19,270	5.9
1973 1/	42,200	9.0	40,200	8.1	26,130	5.3	25,820	11.1	23,700	11.7	20,320	5.5
1974 1/	45,800	8.5	44,800	11.4	28,890	10.6	27,710	7.3	24,070	1.6	21,400	5.3

1/ Estimate provided by USDA and TVA material.

Source: FAO Annual Fertilizer Review for 1960-63, 1964, 1965, 1966, 1972 for 1967-72.

Table 2: Wheat Production, Selected Countries and World Totals: 1961-73

Country	Area (million hectares)								Output (million metric tons)							
	1961-65 average	1967	1968	1969	1970	1971	1972	1973	1961-65 average	1967	1968	1969	1970	1971	1972	1973
USA	19.4	23.8	22.4	19.2	17.6	19.3	19.1	21.7	33.0	41.4	42.9	39.7	36.8	44.0	42.0	47.0
Canada	11.1	12.2	11.9	10.1	5.1	7.9	8.6	10.1	15.4	16.1	17.7	18.6	9.0	14.4	14.5	17.0
Australia	6.7	9.1	10.8	9.5	6.4	7.1	7.8	9.0	8.2	7.5	14.8	10.5	7.9	8.4	6.6	11.7
USSR		(1965-69 average) 68.2			65.2	63.1	58.5	62.5		(1965-69 average) 66.9			80.0	98.8	85.8	95.0
World Total	210.8	222.1	227.7	221.6	210.9	216.1	214.5	222.2	254.3	299.4	332.5	315.5	318.6	353.8	348.4	374.4

Note: Table compiled from statistics in FAO "Production Yearbook, 1971", revised and updated with statistics from FAO "Monthly Bulletin of Agricultural Economics and Statistics", 1973 issues, and from U.S. Department of Agriculture, "World Agricultural Production and Trade", March 1972, September 1973. The 1973 figures are preliminary.

Table 3: INDICES OF COMMODITY PRICES

(constant terms - 1972 = 100)

	Actual				Forecast							
	1967-69	1972	1973	Jan.-March 1974	1974	1975	1976	1977	1978	1979	1980	1985
Petroleum	87	100	118	331	331	331	331	331	331	331	331	331
Food												
Cocoa	145	100	168	173	164	141	150	148	130	125	118	118
Coffee	100	100	103	103	104	109	116	104	101	94	94	94
Tea	132	100	83	88	103	86	73	73	70	67	64	64
Sugar (World)	41	100	108	192	180	135	101	94	84	84	85	90
Sugar (U.S. Preferential)	104	100	92	131	145	123	122	121	122	123	123	115
Oranges/Tangerines	137	100	87	86	86	86	85	85	83	82	82	82
Lemons/Limes	122	100	100	98	98	100	98	96	96	96	96	95
Bananas	119	100	88	75	79	77	75	74	73	72	72	80
Livestock Products												
Beef	-	100	106	87	103	105	103	102	105	107	110	122
Hides and Skins	76	100	104	108	99	99	101	96	101	103	106	106
Grains												
Wheat	119	100	171	220	214	103	171	155	145	132	122	128
Rice	172	100	198	282	228	205	187	170	155	141	131	134
Maize	116	100	145	165	156	147	142	135	129	123	117	121
Grain Sorghum	112	100	138	152	149	140	132	125	118	110	104	106
Fats & Oils												
Coconut Oil	176	100	180	379	234	201	187	160	171	166	157	171
Copra	192	100	208	403	276	240	223	213	203	196	186	204
Groundnut Oil	87	100	105	177	124	107	99	96	91	88	83	91
Groundnuts	87	100	120	172	106	93	86	82	78	75	72	80
Palm Oil	110	100	141	212	146	126	117	113	107	104	98	107
Fishmeal	77	100	188	159	174	159	145	134	130	122	115	126
Soyabean Meal	102	100	170	99	86	70	73	78	86	93	104	113
Non-Food												
Cotton	102	100	137	148	135	115	125	100	100	100	100	100
Jute	120	100	80	67	69	71	72	73	73	73	73	69
Sisal	90	100	184	316	244	157	115	95	83	76	74	71
Wool	92	100	178	142	145	124	115	98	91	91	91	106
Rubber	152	100	164	204	168	148	140	140	140	140	140	132
Tobacco	123	100	86	78	78	79	80	81	82	83	84	84
Timber												
Logs (Lauan)	125	100	139	175	170	152	155	159	163	166	170	179
Logs (Miaugm)	98	100	168	150	159	136	139	142	145	148	152	159
Metals & Minerals												
Copper	151	100	137	160	164	142	134	127	127	127	127	140
Lead	107	100	118	154	128	120	116	108	104	104	107	107
Tin	112	100	107	143	123	118	112	107	102	97	93	103
Zinc	93	100	187	289	255	191	168	149	139	140	140	148
Bauxite	128	100	87	88	127	139	152	164	176	176	182	182
Iron Ore	117	100	88	92	92	82	87	92	101	110	119	128
Manganese Ore	125	100	98	124	124	111	99	96	90	96	102	96
Steel	80	100	110	n.a.	111	108	105	104	101	97	94	95
Fertilizers												
Phosphate Rock	125	100	100	263	269	243	220	205	200	199	197	141
DAP	88	100	109	182	184	158	127	115	107	102	103	103
Urea	144	100	133	300	272	233	196	154	130	117	112	137
Muriate of Potash	91	100	107	115	113	98	91	90	88	87	85	77

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FROM: The Secretary

May 21, 1974

FERTILIZER REQUIREMENTS OF DEVELOPING COUNTRIES

There is attached for information a report entitled "Fertilizer Requirements of Developing Countries" (report No. 446), dated May 15, 1974.

Distribution:

Executive Directors and Alternates
President
Senior Vice President, Operations
Executive Vice President and Vice President, IFC
President's Council
Directors and Department Heads, Bank and IFC

M

November 27, 1974

Dear Mr. Khatri:

Thank you for your letter of November 6, 1974 to Mr. Harold Graves concerning the use of Azotobacter to increase yield of cereal crops.

As you know, the Consultative Group on International Agricultural Research sponsors ten research centers most of which do research on various cereal crops. These research centers are directly responsible for conducting trials and experiments.

It would be more appropriate, however, to bring the matter of Azotobacter up to the Consultative Group's Technical Advisory Committee which is responsible for advising the research centers on the technical/ scientific aspects of cereal crop research. The person to contact is Mr. Peter Oram, Secretary, Technical Advisory Committee. The address is:

Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla
Rome 0100, Italy.

I am also circulating your letter and brochure to some of my colleagues for their information.

With best regards,

Sincerely yours,

Bruce M. Cheek
Deputy Executive Secretary

Mr. A. A. Khatri
Director, Technical
BAFE LAB PVT. LTD.
1233-A Apte Road
Deccan Gymkhana
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cc: Messrs. Neylan, Carmignani, Fransen, Coulter

CBGavino:ia

ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE

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V7-1 " cc: - "M"

Ref. PR 3/3 In reply please mention our subject code ref. and date of this letter

22 NOV. 1974

Dear John,

I should like to thank you for your letter of 5 November 1974 referring to the report of the TAC Sub-Committee on Plant Nutrition.

When this Sub-Committee met in Frankfurt late September it reviewed research needs in the field of soil fertility. I pointed out that the interpretation of research results and the planning of future activities should take into account the rather wide diversity of tropical soils. I had the impression that one was thinking of tropical soils as an extensive homogeneous stretch of land with common characteristics. It is as a follow-up of this discussion that I was asked to prepare a short introduction to the report of this Sub-Committee, pointing to differences in tropical soils and the need for stratification of research to be undertaken in this region. The paper, therefore, can be rather short since no full account of tropical soil characteristics is needed. I hope I can draft something in the near future and then submit it to you for your review and amendments.

I was pleased to learn that you have now jointed the Consultative Group on International Agricultural Research and I am looking forward to a continued cooperation with you.

With best regards,

Yours sincerely,

Rudy

R. Dudal
Chief
Soil Resources, Development and Conservation Service
Land and Water Development Division

Dr. John K. Coulter
Consultative Group on International Agricultural Research
1818 H St., N.W.
Washington, D.C. 20433
U.S.A.

P.S. Could you please let me have a reprint or a photocopy of the paper you presented at the IITA Seminar on Tropical Soil Management.

ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE

ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Via delle Terme di Caracalla, 00100-ROME Cables: FOODAGRI ROME Telex: 61181 FOODAGRI Telephone: 5797

Ref. PR 3/3 In reply please mention our subject code ref. and date of this letter

22 NOV 1974

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Consultative Group on International Agricultural Research
1818 H St., N.W.
Washington, D.C. 20433
U.S.A.

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P.S. Could you please let me have a reprint or a photocopy of the paper you presented at the IITA Seminar on Tropical Soil Management.

(7-73)

WORLD BANK GROUP

ROUTING SLIP	DATE November 8/74
NAME	ROOM NO.
~~Mr. Lejeune~~	
~~Mr. Gautier~~	

	APPROPRIATE DISPOSITION		NOTE AND RETURN
	APPROVAL		NOTE AND SEND ON
	COMMENT		PER OUR CONVERSATION
	FOR ACTION		PER YOUR REQUEST
	INFORMATION		PREPARE REPLY
	INITIAL		RECOMMENDATION
	NOTE AND FILE		SIGNATURE

REMARKS

Please find attached, for your information, a brief Note summarizing the Status of World Bank Group Financing of Fertilizer Manufacturing and Fertilizer Raw Materials Projects.

FROM	ROOM NO.	EXTENSION
Roger Carmignani RC. Acting Chief Fertilizer Unit	E-1028	4348

M

WORLD BANK GROUP FINANCING OF FERTILIZER MANUFACTURING AND FERTILIZER RAW MATERIALS PROJECTS

1. Since 1964, the World Bank Group has participated in the financing of 18 fertilizer manufacturing projects (on stream and under construction) and is considering participation in the financing of an additional 5 fertilizer manufacturing projects (currently at various stages of appraisal and negotiation). Various other projects are under consideration. The attached Table shows a detailed list of projects according to their status.

2. These 23 fertilizer projects (on stream, under construction and under appraisal) are located in 13 different developing countries. Their total capital costs amount to about US$2.6 billion and the World Bank Group financial participation to about US$900 million. After reaching full production by the end of the 1970's, their cumulative contribution to the world supply of nutrients will be substantial: (i) about 3.2 million tons of nitrogen, i.e. about one-third to one-fourth of the forecasted 1980/81 nitrogen production in developing countries; and (ii) nearly 1.1 million tons of P_2O_5 1/, i.e. about one-fourth to one-fifth of the forecasted 1980/81 P_2O_5 production also in developing countries.

1/ Nutrient element in phosphate fertilizers.

Fertilizer Unit
Industrial Projects Department
November 1974

WORLD BANK GROUP FINANCING OF FERTILIZER MANUFACTURING AND RAW MATERIALS PROJECTS SINCE 1964

				In Million US$						Capacity in 000 Tons/Year of Nutrients				
							Loan Capital Financing			N		P_2O_5		
Country	Project	Start-Up Date	Final Products	Estimated Total Cost At Start-Up	Total World Bank Group	Total IFC 1/	IBRD	IDA	Co-financier's	Project	Plant 2/	Project	Plant 2/	Sponsors and Remarks
ON STREAM														
Tunisia	NPK-Engrais	1965	TSP	14	3.5	3.5	-	-	Sponsors/Suppliers	-	-	83	83	Various Sponsors
Senegal	SIES	1968	NPK	12	3.5	3.5	-	-	EIB(2),BNDS(2),FAC(1)	7	7	24	28	EMC (France)
Congo	CPC	1969	Potash (KCl)	95	30.0	-	30	-	EIB(9),BNP(6)	-	-	-	-	Cap: 0.8 million tons/year
Brazil	Ultrafertil	1970	NPK & Urea	105	11.3	11.3	-	-	3/	120	120	75	75	Phillips Petroleum (USA)
India	Indian Explosives	1970	Urea	82	11.5	11.5	-	-	Local Banks/Suppliers	207	207	-	-	ICI (UK)
Pakistan	Dawood-Hercules	1971	Urea	84	35.9	3.9	32	-	AID(14),Others(8)	170	170	-	-	Hercules (USA)
India	Zuari Agrio Chemicals	1973	NP & Urea	75	18.9	18.9	-	-	4/	170	170	30	30	United States Steel
Indonesia	Pusri II	1974	Urea	83	35.0	-	-	35	AID,OECF & ADB (46)	175	221	-	-	Pusri
TOTAL				550	149.6	52.6	62	35		849	895	212	216	
%				(100)	(27)	(10)	(11)	(6)						
APPROVED AND UNDER CONSTRUCTION														
India	Cochin II	1975	NPK	68	20	-	-	20	-	47	291	115	150	FACT
India	Gorakhpur	1975	Urea	23	10	-	-	10	-	51	131	-	-	Fertilizer Corp. of India
Turkey	IGSAS	1976	Urea	130	24	-	24	-	-	233	233	-	-	TPAO - IPRAS
Morocco	Maroc-Phosphore	1975	Phos.Acid/MAP	155	50	-	50	-	KfW(27), BNDE(8)	25	25	495	495	OCP
India	Nangal	1977	Urea	115	58	-	-	58	-	152	230	-	-	Fertilizer Corp. of India
Pakistan	Multan	1977	NP & CAN	125	35	-	35	-	5/	200	240	70	70	Pakarab
India	Trombay IV	1977	NPK	64	50	-	50	-	-	75	304	75	129	Fertilizer Corp. of India
Egypt	Talkha	1977	Urea	135	20	-	-	20	Various Funds(69) 6/	262	360	-	-	El Nasr
Romania	Tecuci	1977	Urea/DAP	201	60	-	60	-	-	225	225	100	100	Tecuci
Tunisia	Gafsa	1977	Phos. Rock	64	23	-	23	-	-	-	-	-	-	Cap: 1.6 million tons/year
TOTAL				1,080	350	-	242	108		1,270	2,039	855	944	
%				(100)	(32)	(-)	(22)	(10)						
UNDER APPRAISAL														
India	Sindri	1977	Urea	188	91	-	-	91	-	145	245	-	156	Fertilizer Corp. of India
India	IFFCO	1978	Urea	221	109	-	109	-	-	228	228	-	-	IFFCO
Indonesia	Pusri III 7/	1977	Urea	187	112	-	112	-	-	262	483	-	-	Pusri
Bangladesh	Ashuganj	1978	Urea	245	33	-	-	33	8/	243	243	-	-	BFCPC
Mexico	Guanomex	1978	Urea	144	50	-	50	-	n.a.	380	380	-	-	Guanomex
TOTAL				985	395	-	271	124		1,258	1,579	-	156	
%				(100)	(40)	(-)	(28)	(12)						
OVERALL TOTAL				2,615	895	52.6	575	267		3,202 7/	4,292 7/	1,067	1,316	
%				(100)	(34)	(2)	(22)	(10)						
UNDER CONSIDERATION														
Sri Lanka	n.a.	n.a.	Urea	n.a.	--------------Undetermined--------------				ADB	--Undetermined--		-	-	-
Burma	n.a.	n.a.	Urea	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		-	-	-
Philippines	n.a.	n.a.	Urea	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		-	-	-
Jordan	Arab Chemicals	n.a.	Phos.Acid/MAP	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		--Undetermined--		-
Egypt	n.a.	n.a.	Phos. Rock	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		-	-	Cap: n.a.
India	Dharamsi Mor.	n.a.	NPK	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		--Undetermined--		-
India	Rajasthan	1978	Phos. Rock	n.a.	--------------Undetermined--------------				n.a.	--Undetermined--		300	300	-
India	Sector Loan	1976/78	n.a.	n.a.	-	-	-	120	-	n.a.	n.a.	n.a.	n.a.	
Pakistan	-	1978	Urea	240	--------------Undetermined--------------				-	262	262	-	-	U.S.Steel, Fauji Foundation

1/ Loan plus equity capital financing.
2/ Total capacity after expansion
3/ AID (16), INCB (14), Phillips (13), Others (24).
4/ Bank of America (12), AID (25).
5/ ADB (27), Abu Dhabi (11).
6/ Arab Fund (22), Kuwait Fund (24), Abu Dhabi Fund (10), Lybian Bank (10), Govt. of Qatar (3).
7/ Pusri III plant capacity includes Pusri II.
8/ ADB, AID, ODM, KfW, Others (85).

Industrial Projects Department
November 1974

M

November 5, 1974

Dear Rudy:

I have received a copy of notes of the meeting called by Vernon Ruttan on the Plant Nutrient Institute and I see that I am to work with you on the tropical soils aspect. I look forward to this very much and would like to have your ideas on any contributions that I might make.

I don't expect to be through Rome until February which is too late to have any discussion before the next TAC meeting; so we will have to work by correspondence.

I received a copy of the draft edition of "Soil Survey in Irrigation Investigations" but unfortunately I have yet to find the time to comment on it, though I should be able to do so fairly soon.

With best regards,

Yours sincerely,

John K. Coulter

Dr. R. Dudal
Land and Water Development Division
Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla
Rome 00100
Italy

JKCoulter:apm

INTERNATIONAL DEVELOPMENT ASSOCIATION | INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT | INTERNATIONAL FINANCE CORPORATION

OFFICE MEMORANDUM

TO: Files

DATE: October 8, 1974

FROM: Anthony Neylan AN

SUBJECT: International Fertiliser Development Centre

Mr John Malcolm of USAID told me per phone this afternoon that the International Fertiliser Development Centre was formally incorporated yesterday, October 7. The Board of Directors, consisting at this stage of Chairman John Hannah and two members, will hold its first meeting on October 11. The Board is expected to have nine members eventually.

Mr Malcolm told me that Mr Don McCune had been nominated for Managing Director and it was expected that he would take up that position about November 1 after his resignation from TVA.

The preliminary draft of a work program for the Centre was expected to be prepared by December 16. The program would be reviewed on January 9 and in final form on January 14 in time for forwarding to TAC for its Rome meeting beginning February 3.

I informed Mr Malcolm of the outcome of the Frankfurt meeting of the TAC Sub-Committee on Plant Nutrition. He offered to act as a channel of communication prior to McCune's appointment as Managing Director between the TAC Sub-Committee and the new Centre.

I consequently addressed a letter to Malcolm to elicit an input on chemical fertiliser research needs for the consideration of the TAC Sub-Committee.

cc: Sir John Crawford
Mr R. Carmignani
Mr H. Graves
Mr V. Ruttan
Mr M. Yudelman

ANeylan:jf

M

A/D/C

The Agricultural Development Council, Inc.

630 Fifth Avenue, New York, N.Y. 10020

Established by John D. Rockefeller 3rd

Tel: 212-757-8566 • Cable: Agridevel New York

October 3, 1974

To: Members and Participants
TAC Subcommittee on Plant Nutrition

From: Vernon W. Ruttan
Subcommittee Chairman

Re: Subcommittee Meeting
Frankfurt, Germany, September 28, 1974

The purpose of this memorandum is to confirm the results of the meeting of the TAC Plant Nutrition Subcommittee in Frankfurt on September 28. A more complete, and perhaps more accurate, set of minutes will be available shortly from Bryan Webster.

The subcommittee agreed to organize its efforts around six topics:

(1) Chemical Fertilizers

This working group will be concerned with strengthening capacity to work on problems of the formulation, distribution and use of chemical fertilizers suited to tropical environments. It will give particular attention to identification of the appropriate institutional relationships between the new international fertilizer institute to be located at Muscle Shoals (Alabama) in association with the TVA to the commercial fertilizer industry (or industry organizations), to existing international crop institutes, and to agencies involved in planning for fertilizer development in LDC's. Peter Oram has been asked to serve as Chairman of the working group. Hassan El-Tobgy, Tony Neylan and F. Biedermann have been asked to serve as members. It is anticipated that the subcommittee may want to draw on the advice of TVA staff. Tony Neylan stands ready to assist in any contacts with the TVA.

(2) Biological Sources of Plant Nutrition

This working group will attempt to determine if there are specific research problems in the field of biological nitrogen fixation, biological approaches to more efficient use of phosphates and others that should be explored in greater depth by TAC or that should represent priority areas for CG support. It is anticipated that the working group will be able to draw heavily on the results of the international conference on grain legumes being held in India in early October as well as on the results of several other recent international conferences and symposia dealing with nitrogen fixation, improvement of seed problems and others. H.C. Pereira has been asked to serve as Chairman of the working group. Peter Dart, Guy Camus and Bryan Webster have been asked to serve as members.

TAC Plant Nutrition Subcommittee Meeting,
Frankfurter Hof, Frankfurt, Germany
September 28, 1974

TAC Members

Dieter Bommer, Head
Institute for Plant Cultivation
and Seed Research
Agricultural Research Center
Braunschweig-Volkenrode
Federal Republic of Germany

H.C. Pereira*
Ministry of Agriculture, Fisheries
and Food
10 Whitehall Place
London, SW1
England

V.W. Ruttan, President
Agricultural Development Council
630 Fifth Avenue
New York, New York 10020

Guy Camus, Director
Office de la Recherche Scientifique
et Technique Outre-Mer
24 Rue Bayard
75008 Paris
France

M.S. Swaminathan, Director General*
Indian Council of Agricultural
Research
Krishi Bhawan
Dr. Rajendra Prasad Road
New Delhi - 1
India

Observers and Consultants

B. Ramamoorthy, Coordinator
All India Coordinated Soil Test
Crop Response Correlation Scheme
Krishi Bhawan
Dr. Rajendra Prasad Road
New Delhi - 1
India

Rudi Dudal, Chief
FAO Soil Resources Service
Via delle Terme di Caracalla,
00100 Rome, Italy

Peter Dart,
Rothamsted Experimental Station
Harpenden
Herts. England AL5 2JQ

F. Biedermann
Director of Biological Development
Agrochem Division
6234 Hattersheim
Okrifteler Strabe 31
Hoechst Aktiengesellschaft
6230 Frankfurt (M) 80
Germany

Donald Plucknett, Chief
Soil and Water Management Division
Office of Agriculture, Rm. 2246 NS
AID
Washington, D.C. 20523

Secretarial

Anthony Neylan
International Bank for Reconstruction
and Development
1818 H Street, N.W.
Washington, D.C. 20433

John Coulter*
IBRD

Brian Webster
Food and Agriculture Organization
Via delle Terme di Caracalla,
00100 Rome, Italy

Peter Oram*
FAO

*Unable to participate

(1) There is a major constraint in scientific knowledge or technology that is unlikely to be overcome in a reasonable time by existing public or private institutions.

(2) There is a reasonable possibility that the potential advances in knowledge in science or technology would lead to a significant contribution to crop production within the next 10-15 years.

Several of the working groups have made preliminary plans for a meeting to firm up the results of their efforts. Arrangements for such meetings should be made through Bryan Webster or Peter Oram at FAO.

The TAC Subcommittee will plan to make a progress report to TAC at the TAC meeting in Rome on February 3-7. It may be desirable for the subcommittee to meet in Rome to discuss the working group reports on the Friday prior to the winter TAC meeting (on January 31).

cc: John Crawford

attachments

(3) Organic Sources of Plant Nutrition

This working group will be concerned with both the potential role of organic sources of plant nutrition and the role of organic materials in rendering chemical fertilizers more effective. Attention will be given to the possibility that the higher prices for chemical fertilizers may increase the economic feasibility of making more effective use of manure and other organic waste materials at the municipal, village and farm level. M.S. Swaminathan has been asked to serve as Chairman of this working group. Donald Plucknett and Rudi Dudal have been asked to serve as members. We anticipate that the section will draw very heavily on the materials that have previously been prepared for the TAC by Swaminathan. Plucknett will make available the result of US experience. Dudal will draw on sources at FAO including the results of a forthcoming conference that will be held in Rome.

(4) Diffusion of Known Technology

This working group will attempt to determine steps that might be taken to assure that the available technology in the areas of chemical fertilizers, biological sources of plant nutrition and organic sources of plant nutrition are fully utilized. It is not expected that activities in this area will be funded through the Consultative Group. Opportunities in this area should, however, be brought to the attention of national programs and bilateral donors. Dieter Bommer has been asked to serve as Chairman of the working group. Rudi Dudal, Donald Plucknett and Guy Camus have been asked to serve as members.

(5) Tropical Soils

The objective of this working group will be to indicate the implications of the complexity of tropical soil, climate and other ecological conditions for any effort that might be undertaken in the area being covered by the other working groups. Rudi Dudal has been asked to serve as Chairman of the soils working group and John Coulter and B. Ramamoorthy as members. It was also suggested that the subcommittee might want to be in contact with G. Uehara of the University of Hawaii.

The material requested from the several international crop institute directors in my letter of August 16 (attached) will be transmitted to the Chairmen of the several working groups as they are received.

The reports of each working group should not exceed fifteen pages. An effort should be made, particularly in working groups (1), (2) and (3) to indicate those areas (if any) that should have a relative high priority for international support. The reports should attempt to identify how (and if) the TAC and the CG should proceed to encourage further work on the priority problems rather than to provide an encycopediec review of the literature. My own criteria for international support include the following:

A/D/C

The Agricultural Development Council, Inc.

630 Fifth Avenue, New York, N.Y. 10020

Established by John D. Rockefeller 3rd

Tel. 212-757-8566 • Cable: Agridevel New York

August 16, 1974

Dr. U. J. Grant, Director-General
Centro Internacional de Agricultural Tropical
Apartado Aereo 67-13
Cali, Colombia, S. A.

Dear Dr. Grant:

At the recent Centers Week sessions in Washington the Technical Advisory Committee (TAC) reported to the Consultative Group (CG) on "Plant Nutrition Research Needs." The TAC Chairman, Sir John Crawford, has asked me to chair a subcommittee to follow-up on the issues outlined in the TAC report to the CG. A copy of the report on Plant Nutrition Needs is enclosed in case you do not have one in your files.

The purpose of this letter, which is going to all Center Directors, is to seek your advice on plant nutrition research needs. Steps are underway to establish an expanded capacity to work on problems of chemical fertilizers suited to tropical environments in cooperation with the TVA at Muscle Shoals. The subcommittee will, therefore, focus its major attention on the opportunities for research and development of biological sources of plant nutrition.

We would appreciate it if you and your staff could provide the subcommittee with information:

(1) What are the potential research and development opportunities for biological sources of plant nutrition for the crops for which CIAT has assumed research responsibility? What work in this area is already underway at CIAT?

(2) What are the potential research and development opportunities for organic sources of plant nutrition for the crops for which CIAT has assumed research responsibility? What work in this area is already underway at CIAT?

(3) What are the potential research and development opportunities for more efficient use of conventional sources of plant nutrition for the crops for which CIAT has assumed research responsibility? What work in the area is already underway at CIAT?

(4) What level of additional staffing (by discipline) would it require for CIAT to make a significant contribution to the solution of the research and development problems outlined above?

(5) What steps would be required, either in the public or the private sector to make the results of the research and development activities that might be conducted by CIAT available for use in crop production?

(6) What length of time would it take for the results of research along the lines outlined in (1), (2), and (3) to begin to have a significant impact on production of the crops for which CIAT is responsible?

(7) How do you evaluate the potential contribution of the research resources that might be devoted to (1), (2) and (3) above, compared to the work that you currently have underway or might engage in in the future, on production of the crops for which CIAT has assumed research responsibility?

In responding to these questions it would be very helpful to discuss both the opportunities and the limitations which you and your staff see with respect to each of the questions outlined above.

Your response would be most helpful to us if we could have it by mid-November. Would you please copy your response to Peter Oram and Anthony Neyland?

Sincerely yours,

Vernon W. Ruttan
President

cc: Sir John Crawford
Mr. Peter Oram
Mr. Anthony Neyland

October 2, 1974

Dear Mr. Roupp:

Thank you for letting me know, in your letter of September 25, about the position of the Charles F. Kettering Foundation with respect to the activities of the Consultative Group on International Agricultural Research. While I am sorry that we are not to have the Foundation's financial participation, I am grateful to you for having taken the time to attend our meeting in July. Your remarks about the Foundation's involvement in nitrogen fixation research will be of interest to a number of donor agencies now consulting on various aspects of plant nutrition, as well as to the Consultative Group's Technical Advisory Committee, and I am taking the liberty of calling this part of your letter to their attention.

Sincerely yours,

Harold Graves
Executive Secretary

Dr. Phillips Roupp
Director
International Affairs
The Charles F. Kettering Foundation
Suite 300
5335 Fox Hills Drive
Dayton, Ohio 45429

cc: Sir John Crawford
Dr. Sterling Wortman
Dr. Joel Bernstein
Mr. Peter Oram

Mr. Baum
Mr. Yudelman
Mr. Neylan

HG:mcj

CHARLES F. KETTERING FOUNDATION / SUITE 300 / 5335 FAR HILLS AVENUE / DAYTON, OHIO 45429 / 513-434-7300

September 25, 1974

Mr. Harold Graves
Executive Secretary
Consultative Group on International
Agricultural Research
1818 H Street, N. W.
Washington, D. C. 20433

Dear Mr. Graves:

Before replying to your letter of August 28, I want to thank you for welcoming the Kettering Foundation's observers to your July meetings so cordially. Mr. Vause, Dr. Newton, and I found the experience informative. It helped us to add to our picture of the coordinated efforts in agricultural research being supported and guided by the Consultative Group. Alternative possibilities for the Kettering Foundation's relationship with the Consultative Group have been considered in the light of what we were able to learn through your generous cooperation.

Your letter detailed the budgetary requirements for ten programs supported by the Consultative Group and additional funds which are likely to be needed in 1975. We understand that the proposed International Plant Nutrient Institute is not being funded at this time but remains under study.

After careful consideration, we have had to conclude that our own budgetary constraints will not make it possible for us to contribute to the current programs of the Consultative Group.

The nitrogen fixation research of the Charles F. Kettering Research Laboratory represents a major, long-term commitment of the Foundation. For this reason, we see no way in which we can make a monetary contribution to the Consultative Group's present programs. Should the International Plant Nutrient Institute be created eventually,

CHARLES F. KETTERING FOUNDATION

Mr. Harold Graves
September 25, 1974

page two

we would like to consider ways to establish a working relationship between the Kettering Laboratory and the Institute.

We are of course eager to be kept informed regarding the status of the proposed Plant Nutrient Institute and to receive regular updatings on the Consultative Group's activities.

With renewed appreciation for the invitation to join you in July.

Yours sincerely,

Phillips Ruopp

Phillips Ruopp
Director
International Affairs

PR/pmc

M

September 27, 1974

Mr. Sayed Marei
Secretary-General
World Food Conference
Food and Agriculture Organization
Via delle Terme di Caracalla
Rome 00100, Italy

Dear Mr. Marei:

The forthcoming World Food Conference promises to be an important step towards the improvement of food supplies and food production in the developing countries. The documents of the Preparatory Committee make it quite clear that fertilizers play a key role in any strategy to help developing countries feed their people. Moreover, the attention of the Conference has been called to the need for research which could lead to improved types of plant nutrients and non-energy alternatives for stimulating plant growth. It therefore seems opportune to write to you about the work of the Consultative Group on International Agricultural Research with respect to plant nutrients, including the proposals which the Group and its Technical Advisory Committee (TAC) have under consideration.

At the August 1-2, 1974, meeting of the Consultative Group in Washington, special attention was given to a report from the TAC on its consideration of how to approach the question of stimulating research on the application of chemical fertilizers to developing country conditions, biological fixation of nitrogen, and organic fertilizers, and to a proposal by the United States to help develop research on the chemical fertilizer part of this problem. The latter proposal was intended to fall within the context of any overall Consultative Group effort on plant nutrition; it would be based on the extensive facilities of the Tennessee Valley Authority (TVA).

The existing international agricultural research centers have a substantial interest in plant nutrition: the International Rice Research Institute (IRRI), the International Institute of Tropical Agriculture (IITA) and the Centro Internacional de Agricultura Tropical (CIAT) have programs on the biological fixation of nitrogen by leguminous and non-leguminous plants. Moreover, work on conventional chemical fertilizers is under way at all the centers, including research into improving efficiency in the use of fertilizers in tropical conditions. An important aspect of this work, in view of the fertilizer shortage, is that the new varieties of wheat and rice, while responding best under controlled fertilizer use, are not dependent exclusively on fertilizers to be superior in yield to traditional local strains. At the same time, the need is recognized to strengthen these programs so as to increase the efficiency of presently available conventional fertilizers and to help define needs for new types of fertilizers.

Accordingly, the Consultative Group's Technical Advisory Committee has recently established a subcommittee to examine the best ways and means of giving effect to the need to mobilize the experience of TVA and other bodies; how best to monitor work at the centers and elsewhere in all relevant fields, and to stimulate further research in each of the three main elements of chemical, microbiological and organic aspects of plant nutrition. The subcommittee will report to TAC at its next meeting in Rome in February 1975. The Consultative Group and TAC have also welcomed the U.S. proposal to establish a non-profit corporation with a multi-national board and staff which would have access to the staff and facilities of the Tennessee Valley Authority and would help develop chemical fertilizer research for tropical conditions. Further plans are awaited by the Group and will be examined by TAC.

In sum, the Consultative Group is seized with the problem of promoting research on more effective means of nourishing the major crops that are practical for small as well as large farmers in developing countries. We hope and expect that this will make an important contribution to the solution of world food problems.

More generally, it is good to note the emphasis which the documents of the Preparatory Committee for the World Food Conference have given to increased agricultural research, including that sponsored by the Consultative Group. It is the hope of the members of the Group that this matter of strengthening international and national agricultural research will receive strong support at the Conference when it meets in Rome in November.

Sincerely yours,

Warren C. Baum

Warren C. Baum
Chairman

cleared in substance with, and cc: Mr. Mashler, UNDP
Mr. Oram, FAO

cc: Sir John Crawford
Mr. Joel Bernstein, USAID
Mr. Yudelman
Mr. Neylan
Mr. Carmignani

BMC/NK/HG/WCB/JBernstein:mcj

#4 M

September 25, 1974

Dr Donald L. McCune
Director
International Fertilizer Development Staff
Tennessee Valley Authority
Muscle Shoals
Alabama 35660

Dear Don,

Thank you for sending copies of the report to Ottawa - they arrived in good time for me to put one directly into the hands of Sir John.

The visit to Muscle Shoals was thoroughly enjoyable - both for the intellectual fare and the opportunity to meet you and your colleagues. I look forward with keen anticipation to the ideas and vigor you will all bring to the international scene.

With kindest regards,

Yours sincerely,

Anthony Neylan

ANeylan:jf AN

E

cc M

CHARLES F. KETTERING FOUNDATION / SUITE 300 / 5335 FAR HILLS AVENUE / DAYTON, OHIO 45429 / 513-434-7300

September 25, 1974

Mr. Harold Graves
Executive Secretary
Consultative Group on International
Agricultural Research
1818 H Street, N. W.
Washington, D. C. 20433

Dear Mr. Graves:

Before replying to your letter of August 28, I want to thank you for welcoming the Kettering Foundation's observers to your July meetings so cordially. Mr. Vause, Dr. Newton, and I found the experience informative. It helped us to add to our picture of the coordinated efforts in agricultural research being supported and guided by the Consultative Group. Alternative possibilities for the Kettering Foundation's relationship with the Consultative Group have been considered in the light of what we were able to learn through your generous cooperation.

Your letter detailed the budgetary requirements for ten programs supported by the Consultative Group and additional funds which are likely to be needed in 1975. We understand that the proposed International Plant Nutrient Institute is not being funded at this time but remains under study.

After careful consideration, we have had to conclude that our own budgetary constraints will not make it possible for us to contribute to the current programs of the Consultative Group.

The nitrogen fixation research of the Charles F. Kettering Research Laboratory represents a major, long-term commitment of the Foundation. For this reason, we see no way in which we can make a monetary contribution to the Consultative Group's present programs. Should the International Plant Nutrient Institute be created eventually, we would like to consider ways to establish a working relationship between the Kettering Laboratory and the Institute.

We are of course eager to be kept informed regarding the status of the proposed Plant Nutrient Institute and to receive regular updatings on the Consultative Group's activities.

With renewed appreciation for the invitation to join you in July.

Yours sincerely,

Phillips Ruopp

Phillips Ruopp
Director
International Affairs

PR/pmc

DISTRIBUTION

TELEX FROM: ROME
Sept. 24, 1974

INCOMING TELEX

AGRICULTURE & RURAL DEVELOPMENT

M

YUDELAMAN FROM KOFFSKY DRAFT LETTER RE FERTILIZER INSTITUTE ACCE
PTABLE AS IS BY WEBSTER WITH ORAM AWAY AND BY SECRETARYGENERAL
STOP REGARDS +HUYSER +

Form No. 27
(3-70)

INTERNATIONAL DEVELOPMENT ASSOCIATION | INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT | INTERNATIONAL FINANCE CORPORATION

OUTGOING WIRE

TO: COULTER
11 DELLCROFT WAY
HARPENDEN
HERTS.

Tele: HARPENDEN 60589

DATE: SEPTEMBER 13, 1974

CLASS OF SERVICE: FULL RATE
Ext. 3454

COUNTRY: ENGLAND

TEXT:
Cable No.:

HAVE TODAY RECEIVED FOLLOWING CABLE FROM DIOUF QUOTE PLEASED INFORM YOU DOCTOR HARRY WILL RESEARCH COORDINATOR AND OMER KOFFI FERTILIZER TRIALS COORDINATOR MEETING YOU DAKAR STOP RESEARCH STATIONS ALREADY NOTIFIED OF VISITS AND TRANSPORT ARRANGED ACCORDINGLY STOP REGARDS DIOUF UNQUOTE

REGARDS

CHEEK

NOT TO BE TRANSMITTED

AUTHORIZED BY:

NAME Bruce M. Cheek

DEPT. Agriculture & Rural Development

SIGNATURE B. Cheek
(SIGNATURE OF INDIVIDUAL AUTHORIZED TO APPROVE)

REFERENCE:

CLEARANCES AND COPY DISTRIBUTION:

BMC:mcj

For Use By Communications Section

Checked for Dispatch:

ORIGINAL (File Copy)

(IMPORTANT: See Secretaries Guide for preparing form)

DISPATCHED

SEP 13 7 44 PM 1974

COMMUNICATIONS

M

September 12, 1974

Mr. George F. Darnell

John K. Coulter JKC

Report of Dr. Ahmad Safed Khan, University of Agriculture, Lyallpur

I have not been able to read this document in detail but I presume that economists would be major users since it deals with economic production functions.

It is impossible to say how good is the agronomic element in this report. It deals with a 1000 wheat fertilizer trials on irrigated land and whilst impressive yield functions were derived from the data, there are no graphs to show how well the data actually fits these functions.

Perhaps one of the economists might look at this document to see if the data has any value for measuring returns at varying costs of fertilizer.

Attachment

JKCoulter:apm

M

Mr Anthony Neylan August 23, 1974

George F. Darnell

Terms of Reference -
Visit to TVA and Auburn University

On August 26, 1974, you will proceed to Muscle Shoals, Alabama, to represent Sir John Crawford, Chairman of the Technical Advisory Committee, and Dr Vernon Ruttan, Chairman of the TAC Sub-Committee on Plant Nutrition, at a meeting to be held at the Headquarters of the Tennessee Valley Authority to discuss the possibility of the formation of an International Fertiliser Development Centre.

On leaving Muscle Shoals, on or about August 30, 1974, you will proceed to Auburn, Alabama, for discussions with staff of the Department of Fisheries and Allied Aquaculture, University of Auburn, in connection with the work of the TAC Sub-Committee on Aquaculture.

Upon your return to the Bank on September 2, 1974, you will prepare a report on your missions.

ANeylan/GDarnell:jf AN

Form No. 27
(3-70)

INTERNATIONAL DEVELOPMENT ASSOCIATION	INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT	INTERNATIONAL FINANCE CORPORATION

OUTGOING WIRE

TO: ORAM
FOODAGRI
ROME

DATE: AUGUST 22, 1974

CLASS OF SERVICE: LT Telex (EXTN 4823)

COUNTRY: ITALY

TEXT:
Cable No.:

AVAILABLE PLANT NUTRITION MEETING FRANKFURT SEPTEMBER 28 GRATEFUL TICKET AUTHORISATION STOP TAC CHAIRMAN AND SUBCOMMITTEE CHAIRMAN RUTTAN HAVE ASKED ME REPRESENT THEM BOTH TVA SEMINAR MUSCLE SHOALS ALABAMA AUGUST 27 THROUGH 29 STOP ALSO PROPOSE VISIT AQUACULTURE CENTRE AUBURN ALABAMA AUGUST ~~29~~ 30 IN CONNECTION AQUACULTURE SUBCOMMITTEE STOP GRATEFUL CABLED AUTHORISATION THIS TRIP IN ORDER CLAIM LATER REIMBURSEMENT FROM TAC REGARDS

NEYLAN

NOT TO BE TRANSMITTED

AUTHORIZED BY:

NAME A.A. Neylan

DEPT. Agriculture & Rural Development

SIGNATURE A.A. Neylan
(SIGNATURE OF INDIVIDUAL AUTHORIZED TO APPROVE)

REFERENCE: ANeylan:jf

CLEARANCES AND COPY DISTRIBUTION:

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(IMPORTANT: See Secretaries Guide for preparing form)

Checked for Dispatch:

IMPORTANT: See Secretaries Guide for preparing form

ORIGINAL (File Copy)

DISPATCHED
AUG 22 10 36 PM 1974
COMMUNICATIONS

REFERENCE: Wahlen:jl

SIGNATURE: (Signature of individual authorized to approve)

DEPT: Agriculture & Rural Development

NAME: A.A. Wahlen

AUTHORIZED BY (Name and signature):

For Use by Communications Section

CLEARANCES AND COPY DISTRIBUTION:

NOT TO BE TRANSMITTED

AUTHORISATION THIS TRIP IN ORDER CLAIM LATER REIMBURSEMENT FROM TAC REGARDS

AUGUST ~~28~~ 30 IN CONNECTION AQUACULTURE SUBCOMMITTEE STOP GRATEFUL CABLED

THROUGH 29 STOP ALSO PROPOSE VISIT AQUACULTURE CENTRE AUBURN ALABAMA

ASKED ME REPRESENT THEM BOTH TVA SEMINAR MUSCLE SHOALS ALABAMA AUGUST 27

AUTHORISATION STOP FAO CHAIRMAN AND SUBCOMMITTEE CHAIRMAN RUTTAN HAVE

AVAILABLE PLANT NUTRITION MEETING FRANKFURT SEPTEMBER 28 GRATEFUL TICKET

WAHLEN

CABLE NO.: TEXT:

COUNTRY: ITALY

TO: [illegible] FOODAGRI ROME

CLASS OF SERVICE: TL (EXTN 4823)

DATE: AUGUST 22, 1974

OUTGOING WIRE

INTERNATIONAL DEVELOPMENT ASSOCIATION | INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT | INTERNATIONAL FINANCE CORPORATION

Form No. 27

Form No. 27
(3-70)

INTERNATIONAL DEVELOPMENT ASSOCIATION	INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT	INTERNATIONAL FINANCE CORPORATION

OUTGOING WIRE

TO: ORAM
FOODAGRI
ROME

DATE: AUGUST 21, 1974

CLASS OF SERVICE: LT

(Extn 4823)

COUNTRY: ITALY

TEXT:
Cable No.:

PLANT NUTRITION SUBCOMMITTEE MEETING SEPTEMBER 28 FRANKFURT STOP BERNSTEIN UNDERSTANDS FOUNDATIONS OFFER WAS FOR EMPLOYMENT OF ASSISTANCE FROM OUTSIDE TAC STOP GRAVES CONCURS THAT FRANKFURT MEETING WOULD BE PROPER CHARGE TO TAC ADMINISTRATIVE BUDGET STOP UPON RECEIPT OF [redacted] UPDATED TAC [redacted] ACCOUNTING CGIAR SECRETARIAT CAN CONSIDER PROVIDING ADDITIONAL FUNDS STOP LAST ACCOUNTING APPEARING IN OUR FILES IS AS OF JUNE 30 1973 REGARDS

NEYLAN

NOT TO BE TRANSMITTED

AUTHORIZED BY:

NAME A.A. Neylan

DEPT. Agriculture & Rural Development

SIGNATURE ______
(SIGNATURE OF INDIVIDUAL AUTHORIZED TO APPROVE)

REFERENCE: ANeylan:jf

ORIGINAL (File Copy)
(IMPORTANT: See Secretaries Guide for preparing form)

CLEARANCES AND COPY DISTRIBUTION:

cc: Mr Graves

For Use By Communications Section

Checked for Dispatch: ______

ORIGINAL (File Copy)

DISPATCHED

AUG 21 10 02 PM 1974
COMMUNICATIONS

REFERENCE: AANeylan:ll

DEPT. Agriculture & Rural Devel.

NAME: A.A. Neylan

CC: Mr. Graves

NOT TO BE TRANSMITTED

OUTGOING WIRE

DATE: AUGUST 21, 1974

CLASS OF SERVICE: LT

(Ext. 4023)

WRITE TO: ORAM
FOODAGRI
ROME

COUNTRY: ITALY

TEXT:

NEYLAN

PLANT NUTRITION SUBCOMMITTEE MEETING SEPTEMBER 28 FRANKFURT STOP
BERNSTEIN UNDERSTANDS FOUNDATIONS OFFER WAS FOR EMPLOYMENT OF ASSISTANCE
FROM OUTSIDE TAC STOP GRAVES CONCURS THAT FRANKFURT MEETING WOULD BE
PROPER CHARGE TO TAC ADMINISTRATIVE BUDGET STOP UPON RECEIPT OF ~~[illegible]~~ UPDATED
TAC ACCOUNTING CGIAR SECRETARIAT CAN CONSIDER PROVIDING ADDITIONAL FUNDS
STOP LAST ACCOUNTING APPEARING IN OUR FILES IS AS OF JUNE 30 1973 RETURNS

FORM NO. 249
(7–74)

WORLD BANK GROUP

INCOMING MAIL

DATE: AUG 30 1974

	Mr. H. Adler	A1042		Mr. Knox	A813
	Mr. J. Adler	E624		Mr. Krieger	B906
	Mr. Alter	A908		Mr. Lari	D1032
	Mr. Bart	F718		Mr. Lejeune	A1013
	Mr. Baum	E1023		Mr. McNamara	E1227
	Mr. Bell	A613		Mr. Muller	N436
	Mr. Benjenk	E723		Mr. North	D1032
	Mr. Broches	E923		Mr. Nurick	E915
	Mr. Cargill	E1236		Mr. Paijmans	C702
	Mr. Chadenet	E1204		Mr. Rayfield	N434
	Mr. V. C. Chang	E516		Mr. de la Renaudiere	C302
	Mr. Chaufournier	A313			
	Mr. Chenery	E1239		Mr. Rotberg	E427
	Mr. Wm. Clark	E823		Mr. Thalwitz	A210
	Mr. Clarke	D1029		Mr. Tims	D428
	Mr. Damry	A1219		Mr. Twining	N635
	Mr. D. A. de Silva	N635		Mr. Van der Meer	A507
	Diamond	C502		Mr. Van der Tak	E1023
	Mr. Fowler	A1219		Mr. Votaw	C602
	Mr. Gabriel	E516		Mr. Wapenhans	A712
				Mr. Weiner	A513
②	Mr. Graves	E1039		Mr. Wiehen	C1001
	Mr. Gulhati	D530		Mr. Wiese	A837
	Mr. Hittmair	E427		Mr. Willoughby	G1050
	Mr. Hoffman	E823		Mr. Wright	A307
	Mrs. Hughes	D529	①	BMC	
	Mr. Husain	A1136			
	Mr. Kirmani	A610	③	JC ④ CJ	
	Mr. Knapp	E1227			

FROM: Incoming Mail Unit, Room F–126, Extension 2023

OUTGOING TELEGRAM

AUG 21, 1974

ADDRESSEE (Note: X-out errors. Do not erase)

PROF GUY CAMUS
ORSTOM PARIS

DR EL [illegible] TOBGY
FORDLEB BEIRUT

DR PEREIRA
MINAGRIC LONDON

DR SWAMINATHAN
AGRISEC NEW DELHI

MR ANTHONY NEYLAN
INTBAFRAD WASHINGTON

DR PETER DART
ROTHAMSTED EXPERIMENTAL STATION
HARPENDON
HERTS
UNITED KINGDOM

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LT MCI	106 AA	21/8	12

MESSAGE

CHAIRMAN RUTTAN WISHES CONVENE FIRST MEETING TAC SUB COMMITTEE PLANT NUTRITION FRANKFURT GERMANY TWENTY EIGHT SEPTEMBER STOP OBJECTIVE AGREEMENT WORKPLAN ALLOCATION RESPONSIBILITIES PARTS PLAN TO MEMBERS SUB-COMMITTEE ARRANGEMENTS CONTACT MAIN E WORKERS ON CHEMICAL, BIOLOGICAL, ORGANIC SOURCES PLANT NUTRIENTS AND APPROPRIATE INDUSTRIAL ORGANIZATIONS STOP WEBSTER WILL ATTEND AS SECRETARY STOP MEETING TO BE HELD CONFERENCE ROOM 7 HOTEL FRANKFURTER HOF KAISER PLATZ FRANKFURT 9 A.M. TO 5 P.M. TWENTY EIGHT STOP PLEASE CABLE ME SOONEST FOODAGRI ROME YOUR AVAILABILITY SO THAT TICKETS TRAVEL AUTHORIZATIONS CAN BE SENT YOU REGARDS

ORAM

4 –
3 –
2 –
1 –

PROGRAMME TF 5549

	Name	Initials	Date	Hour (0000-2400)
Drafted	P.A. Oram	PAO	21.8.74.	
Cleared	P.A. Oram	PAO	21.8.74.	

Authorized (Name, Title and Signature)
P.A. Oram, Secretary, TAC

DISTRIBUTION OF COPIES

DG c.c. Prof. Bommer (B 417)
DDG Prof. Ruttan (B 417)
Crawford (")
Graves (")
Yriart (DDD)
ODG

FILING CODES: PR 3/10

AFS 90-4 1272 200.M

RECEIVED

1974 AUG 30 PM 3: 14

COMMUNICATIONS
SECTION

— Fertilizer

(Ornamental Washington)

Fertilizer

Mr. Robert S. McNamara June 27, 1974

Warren C. Baum

Fertilizer Unit - Work Program

1. Attached are the proposed terms of reference and work program for FY75 for the new Fertilizer Unit to be established immediately in the Industrial Projects Department, together with a brief description of the Unit's longer-term objectives.

2. It is important that the Unit be launched expeditiously, and work has in fact already started. We intend to staff it from within the Bank Group with two of the most qualified senior people we have in the fertilizer field, Mr. R. Carmignani, an industrial economist who is to head up the Unit initially, and Mr. D. Brown, a chemical engineer. Before joining the Bank Mr. Carmignani gained broad experience in the field while with OECD, and Mr. Brown has played a key role in helping to formulate and push forward most of the Bank's recent fertilizer projects.

3. The incremental budget requirements for the Unit (excluding overhead) are estimated at about $132,000 for FY75 and will cover the salaries of Messrs. Carmignani and Brown, some 230 man-days of consultant time, as well as their respective travel. Since liaison with other organizations working in the areas of fertilizer and food, and help in project preparation will be major elements of the Unit's work, travel will be fairly heavy. The Unit will also include a junior agricultural economist but this position will be provided out of the authorized FY75 budget of the Industrial Projects Department.

4. I draw your attention to the contribution (90 man-weeks) that various other Bank Group units are expected to make. While this will put some additional strain on them, these tasks will be rather broadly distributed in the rest of the Bank and, at least in part, are already planned. I hope therefore they can be fulfilled with the already budgeted staff resources.

5. Finally, I do not expect at this moment that in subsequent years the Unit will need to be built up beyond the three positions now planned for FY75, although this can only be firmly determined once the work of the Unit is further advanced.

6. You have tentatively authorized two positions for this purpose, to be taken from the FY75 contingency. May I now have your formal approval for the estimated budget requirements of $132,000.

WCBaum:rma

cc: Mr. John Adler

BANK GROUP FERTILIZER PLANNING AND MONITORING UNIT
OBJECTIVE, FUNCTIONS AND FY75 WORK PROGRAM AND BUDGET

A. Objectives

To coordinate the planning of Bank Group assistance, in the form of both finance and advisory services, for improved supply and use of fertilizers in developing countries; to devise a coherent strategy and policy to this end taking account of worldwide trends of demand and supply; and to monitor Bank Group progress towards the objectives.

B. Organization and Role in Bank Group

The Unit is to be established immediately. It will consist during FY75 of two senior staff (Mr. R. Carmignani, an industrial economist who will be responsible for launching the Unit, and Mr. D. Brown, a chemical engineer) and a junior agricultural economist who is also expected to be obtained from within the Bank Group. Both Mr. Carmignani and Mr. Brown are senior and experienced staff members, who have worked in the fertilizer field in the Bank and elsewhere. Mr. Carmignani's appointment is an interim one, to allow time for a permanent chief of the Unit to be selected. The Unit will form part of the Industrial Projects Department and will report to its Director.

The Unit will utilize available expertise from other parts of the Bank Group and elsewhere whenever possible. The Unit will also employ consultants to carry out specific technical assignments such as preinvestment studies and to broaden its data collection effort throughout the world. Operational activities in the fertilizer sector (i.e. lending, advisory work, and country sector studies) will continue to be carried out by the Industrial Projects Department, the Projects Departments in the Regions and CPS, the Regional Program Departments, and IFC as well as the UNIDO/IBRD Cooperative Program (CP) Units. For research, data collection, and Bankwide policy support the Unit will also utilize facilities currently available elsewhere in the Bank Group (particularly in the Agriculture units of CPS and DPS) and outside the Bank. The Units' staff will only be used for these purposes to fill in existing gaps or to participate in particularly important or sensitive operations. Its primary tasks will therefore be to ensure that an adequate data base and intelligence service exist, to prepare an overall Bank strategy and work program, to monitor its progress, and to lead or participate in key activities.

The Unit will also be a focal point of contact with relevant outside organizations including industry. A large number of institutions (national, international, public and private) are concerned with the supply and use of fertilizer. However, their activities are frequently unrelated to each other, are overlapping and even duplicating, and in some instances not adequately focused on the critical issues. Concerted international action in the fertilizer field -- difficult as it will be to bring about -- can result only from close liaison among these individual activities. From the outset, therefore, the Unit will work toward bringing these different efforts more closely together and will support any efforts to establish an effective international co-ordinating mechanism in the field.

C. Specific Functions

The Unit will:

1. Ensure that an adequate data gathering system is established within the Bank and outside to provide up-to-date intelligence on worldwide trends in fertilizer demand, supply, costs, prices, international trade and marketing, with special reference to the needs and resources of the developing countries;

2. Assemble and process the above data to: (a) develop and keep up-to-date estimates of the present and future supply/demand balance for the world as a whole and for developing countries, with particular emphasis on major fertilizer consuming countries or group of countries; (b) make recommendations as to the strategy that the Bank Group should follow and the specific action it should take to rationalize the international pattern of fertilizer investment and trade in order to bridge supply gaps or avoid potential oversupply situations; and (c) encourage, in cooperation with Bank Group operating units, specific investment, trade and other actions in producer and/or consumer countries, particularly in the developing world, consistent with this strategy;

3. Formulate, in cooperation with the relevant operational units of the Bank Group, and keep under continuous review a 5-year program of lending (for new production capacity, better utilization of existing capacity, and related purposes), advisory services to developing countries, and country sector work. Particular attention would be paid to the requirements of countries with the most urgent food and fertilizer requirements (e.g. India);

4. Monitor continuously all Bank Group activities in the fertilizer field to assure consistency with the objectives of the 5-year program; and

5. Maintain close liaison with other organizations outside the Bank, including the fertilizer industry.

../3.

As part of the above functions, the Unit will:

6. Keep abreast of plans and projects around the world for additions to fertilizer production capacity;

7. Investigate the availability of capital and know-how for investment in fertilizer plants in developing countries;

8. Advise countries, including oil- and natural gas-rich countries, on potential investment opportunities and help them in the initial preparation of projects;

9. Follow trends in availability and cost of equipment and engineering services for expansion of fertilizer production capacity in developing countries;

10. Maintain up-to-date information on developments in capital, feedstock, and transport costs of fertilizer production and marketing;

11. Identify possible measures for reducing capital costs, for increasing capacity utilization, and for improving plant efficiency of fertilizer production in developing countries;

12. Identify gaps in the adequacy of national and international research on ways of improving effectiveness of fertilizer use in developing countries as well as on nutrient forms other than chemical fertilizer;

13. Establish liaison with other relevant organizations and entities involved in fertilizer promotion, production and distribution such as the fertilizer industry; UN agencies (FAO, UNIDO); bilateral and multinational financial institutions; EEC, OECD, OPEC, IDCAS; the Consultative Group on International Agricultural Research; commercial organizations; COMECON.

D. Work Program for FY75

It is important that the Unit start its work expeditiously, particularly since fertilizer problems are expected to be most acute over the next two or three years. Therefore, at least initially, the Unit will be staffed from within the Bank Group. In view of other existing commitments of the Unit's two senior people (Messrs. Carmignani and Brown) and the fact that the third staff member is not expected to be available until early September, it has been assumed that the Unit's manpower availability in FY75 will amount to 80 man-weeks. It must again be stressed that the Unit can effectively do its work only with the support from other parts of the Bank Group; this is the underlying assumption in the following preliminary program.

PRELIMINARY WORK PROGRAM FOR THE FERTILIZER UNIT (F.U.) IN FY75
(in man-weeks)

Major Tasks and approx. time for Completion	Direct Input by F.U.	Other Bank Group Supporting Units	Consultants	Total	Prime Responsibility for Task
August 1974					
1. Development of detailed work program for F.U. and other Bank Group supporting units for FY1975.	4	(CPS, DPS, Regions) 6	-	10	F.U.
October/November 1974					
2. Identification of principal constraints on increasing fertilizer output and production capacity from existing plants.	6	(IPD, IFC, UNIDO CP) 10	4	20	F.U./UNIDO CP
3. Review of existing data and initial contacts with industry and other organizations to agree on systems and formats for data collection.	6	(DPS Commodities, DRC, IFC FAO CP) 10	4	20	F.U./DPS Com.
4. Establishment of a priority list of LDC countries and projects for possible Bank Group action in calendar 1975 (financial, promotional, and advisory, including potential for joint ventures).	6	(Regions, IFC, IPD, CPS Agr. UNIDO CP) 6	4	16	F.U.
December 1974					
5. Identification of major factors which influence trade, distribution and promotion of fertilizers and impact of such factors on global fertilizer strategy.	8	(DPS, Regions, CPS Agr. IPD) 6	4	18	F.U./FAO CP
February/March 1975					
6. Data collection -- on basis of formats developed under (3) above -- to update global demand and supply forecasts and outline of a proposed future investment and trade strategy.	6	(CPS Agr., DPS Com., IPD, FAO CP) 10	6	22	F.U./DPS
7. Evaluation of present and forecasts of ocean freight rates.	-	(CPS Trans.) 8	4	12	CPS Trans.
8. Preparation of a Bank-wide Five-Year Work Program.	3	-	-	3	F.U.
June 1975					
9. Review of schemes for financing the international fertilizer trade including bilateral export schemes and the need for and feasibility of a Fertilizer Export Fund.	6	(DPS, CPS) 4	4	14	F.U./DPS
10. Identification of major gaps in agricultural research related to and proposals for the promotion of fertilizer use.	5	(CPS Agr., DPS, Regions, IPD, FAO CP) 15	8	28	F.U./CPS Agr.
Continuous					
11. Project identification and co-ordination of initial project preparation and technical assistance.	22	(IFC, IPD, UNIDO CP) 13	8	43	F.U.
12. Liaison with Industry and other organizations.	8	2	-	10	
TOTAL	80	90	46	216	

Industrial Projects Dept.
June 27, 1974

The work program, and particularly the manpower allocation from other participating Bank units, should be considered no more than a general indication of what the Unit should attempt to achieve during its first year of existence. Changes in emphasis and possibly a reduction in coverage may become necessary as we proceed. Though the Unit's work will help determine actions needed to ease the fertilizer shortage in the short term, it will be directed primarily toward updating supply and demand forecasts and preparing an outline for a proposed long-term investment and trade strategy. Given limited manpower, part of the assignments initially cannot be treated in much depth but they will be undertaken to launch the proper action in relation to the Unit's main objectives.

E. Direct Budget of the Unit for FY75 (excluding overhead)

1.	Unit Staff (19 man-months)1/	--	$42,000	
2.	Consultants (230 man-days @ $160/day)	--	37,000	
3.	Travel for Unit Staff, 15 trips @ $1,500/trip	--	22,500	
4.	Travel for Consultants, 10 trips @ $1,300/trip	--	13,000	
5.	Subsistence Expenses while travelling for Unit Staff and Consultants (430 man-days @ $40/day)	--	17,200	
			$131,700	say $132,000

1/ Direct salaries only; does not include salary of agricultural economist who will be on budget of Industrial Projects Department.

Industrial Projects Dept.
June 27, 1974

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

1818 H St., N.W. Washington, D.C. 20433 U.S.A.
Telephone (Area Code 202) 477-3592
Cable Address – INTBAFRAD

M

June 10, 1974

TO: Center Directors and Members of TAC

FROM: Executive Secretariat

SUBJECT: World Fertilizer Situation

Reference is made to the Secretariat memorandum of March 7, 1974, on the above subject and to the June 10 Provisional Schedule of Events for the 1974 International Centers Week, which indicates that plant nutrition will be on the agenda of both TAC and the CG.

To help in preparing for these discussions, two recent World Bank papers are enclosed. One is the report "Fertilizer Requirements of Developing Countries" issued on May 15, 1974. The other is "Issues Relating to the Fertilizer Situation", a discussion paper at a conference sponsored by the World Bank and the Agricultural Development Council at Princeton, also in May.

Attachments (2)
BMC:mcj

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

ASSISTANT
ADMINISTRATOR

JUN 4 1974

THE AUSTRALIAN NATIONAL UNIVERSITY
11 JUN 1974
PROF. J. G. CRAWFORD

Mr. W. David Hopper
President
Canadian International Development
Research Center
P. O. Box 8500
Ottawa, Canada

Dear Dave:

It has occurred to me that your efforts to appraise the international plant nutrition institute proposal that I presented for TAC consideration, or alternatives, could benefit from a paper done for us by TVA staff in early April. This deals only with that part of the plant nutrition research that we had suggested as best done at Muscle Shoals. I am attaching a copy, and regret having delayed in transmitting this to you.

Best regards.

Sincerely yours,

Joel

Joel Bernstein

Attachment: a/s

cc: Sir John Crawford ✓

Fertilizer Technology - Adequacy in Relation to the World Food Situation

Food production in most of the LDC's will have to double by the end of this century just to maintain the present inadequate level of nutrition. And, because of inaccessibility and the high cost of bringing additional land under the plow, most of the projected increased production will have to come from increased yields. One of the major inputs required for these increased yields is chemical fertilizer. Thus, the ability of the LDC farmer to have access to and be able to profitably use chemical fertilizer is a critical consideration in national and international goals for increased food production.

Fertilizer is a costly input. In the United States, it is estimated that about $4 billion will be spent on fertilizers in 1974. The consideration assumes greater importance for the LDC farmer when often fertilizer prices are comparatively even higher than in the United States. In both cases, the amount of fertilizer used (assuming availability) will depend to a considerable extent on the profitability of use. Where high price, limited availability, and limited capital or credit for purchasing are often the case for the LDC farmer, a higher margin of return commonly is required to induce usage.

The considerations require that we not only be concerned with the price of the fertilizer, but with its efficiency in meeting crop needs. It confronts us with the question of the adequacy of fertilizer production and marketing technology. We rightly approve investment in research designed to develop higher yielding varieties of the basic food crops to develop more effective "crop technology." As we propose to show further along, we seem to have been less concerned about the adequacy of, or need for, improved technology dealing with the production and marketing of fertilizer. The assumption is made that a reasonable level of research is done on fertilizer usage as part of the agronomic research in crop improvement programs (e.g. as in IRRI on rice or at CIMMYT on corn and wheat).

Fertilizer Technology--A Historical Perspective

In reviewing the worldwide development of fertilizers and fertilizer production and marketing technology, two very significant points are apparent. In the first place--in contrast to crop production research--fertilizer production research is restricted to a very small number of institutions. In the United States, a high proportion of the effective fertilizer production research is done by, or with the support of, the National Fertilizer Development Center of the TVA at Muscle Shoals, Alabama. Elsewhere there is nothing in fertilizer technology research and development that compares with the university and state experiment station efforts for crop improvement. The fertilizer industry, especially in Western Europe and Japan, has some R&D activity; but it is generally recognized that their effort in developing of new technology is limited indeed. Second, practically all of the present day fertilizer technology has been and is aimed at producing fertilizers for farmers in the developed regions in temperate climates. The LDC's, where population growth is the greatest and food production is already critical, lie primarily in the tropics and subtropics. Even though the climate and the physical characteristics of the soil in large areas of the tropics appears to be conducive to highly productive agriculture, these areas--even more than temperate agriculture--must rely on the liberal use of chemical fertilizer. The tacit assumption has been that fertilizers developed for use in the temperate zones are equally good for the tropics. Yet, careful inspection of differences in climate, soils, crops and agriculture in general reveals that this assumption is not entirely valid. Agronomic results are also confirming these doubts.

As a matter of fact, in considering the current and projected magnitude of fertilizer input both in the developed and the developing regions, we question the adequacy of investment in general for R&D in fertilizer technology.

World fertilizer use in 1973 exceeded 77 million tons of nutrients. However, gross inequities exist: The LDC's as a whole are using only about 20% of the total or about 15.5 million metric tons. By 1980 fertilizer use is estimated to reach 114 million metric tons of nutrients. Even though the LDC's are expected to increase use more rapidly than the developed countries, they are still expected to be using only 26% or about 29.5 million tons of nutrients.

It is estimated that in 1973 upwards to $30 billion were spent on fertilizers--about $21.5 billion in the DC's and $8.5 billion in the LDC's. By 1980, assuming the same price per ton of nutrient, this could balloon to almost $46 billion--$29.6 billion in the DC's and $16.3 billion in the LDC's.

Our best estimates are that current expenditures for actual research on new and improved fertilizers (excluding agronomic work) to be less than $40 million annually in the free world.

<u>Potential for Advances in Fertilizer Technology</u>

Use of the right amount of the right kinds of fertilizers in the right way can produce dramatic results in increased crop production. But often overlooked is the fact that, even under the best of circumstances, utilization of applied fertilizer is low. For example, in the United States the best corn farmer can expect to recover no more than 40%-45% of the applied nitrogen. A small--say 5%--may remain in the soil to be used by a following crop, but most of that not taken up by the corn is lost by leaching or volatilized to the atmosphere. The picture is often more disturbing in the case of phosphorus. A corn crop in the United States usually would take up no more than 20%-25% of that applied specifically for that crop. The remainder is "fixed" in the soil thus rendering it unavailable or difficultly available to future crops.

While the picture of utilization of applied fertilizer in the United States seems to hold considerable room for improvement, the situation in the tropics appears to hold much more. Higher soil temperatures, coupled with higher rates of chemical and biological activity and accentuated leaching, result in even lower nitrogen uptake. And, a large part of the soils of the tropics, because of their even higher "fixing" characteristics, are notorious in their ability to "tie up" applied phosphatic fertilizers.

Recognizing that these conditions exist, is there evidence that a realizable potential exists for substantially improving fertilizer technology for enhancing the utilization of N and P applied as fertilizer? We have evidence to indicate that substantial progress could be made with greater investment in research designed to produce superior fertilizer technology for the tropics. For example, sulfur-coated urea, a fertilizer designed to modulate the rate of nitrogen release in the soil more in keeping with plant uptake requirements, has shown up to 50% greater efficiency in N use. This was obtained with rice under intermittent or delayed flooding. This result has been obtained with relatively modest investment in fertilizer technology research. Based on what we know

now, there is reason to believe that expanded research on fertilizer technology for tropical agriculture could result in:

- Fertilizers with improved transport and handling characteristics permitting greater use of bulk shipment and handling and reducing losses.
- Higher analysis products to materially reduce transport, handling, and marketing costs. Marketing costs in the LDC's may make up over 50% of the price paid by the farmer.
- Cheaper and more effective processes that permit more extensive use of domestic raw materials.
- Processes to use lower grade raw materials.
- More efficient utilization of applied nutrients. Attaining efficiencies common in temperate agriculture would be an improvement of 25%-30% over present; gains even beyond this would be probable.
- Better balanced fertilizers. Secondary (Ca, Mg & S) and micro-nutrients.
- Improved marketing systems that would assure adequate fertilizers at the right place and time at minimum cost.
- More uniformity of supply and thus decreased oscillation in price.

An International Fertilizer Technology Center for the LDC's

In view of the important role that fertilizer must play in increased LDC food production, and the potential for improved fertilizer technology for these countries, how best can this technology be generated? If we were talking about crop improvement technology, then we might consider the feasibility of an IRRI-like center. Yet this analogy is of but limited application. While IRRI generates new technology (new varieties), its success depends in large measure on the existence of country-level IRRI's (national rice research program) to which it can link. An international fertilizer technology center could not reasonably expect to be linked to country-level fertilizer technology centers in each of the LDC's. As mentioned earlier, in the United States we have primarily the National Fertilizer Development Center at TVA; we do not have--could not afford--state-level counterparts. And, in other developed countries, this job is left almost entirely to fertilizer manufacturers who invest very inadequately in research.

Considering the success of TVA in generating improved fertilizer technology for the United States in particular, and the developed countries of the temperate zones in general, a reasonable approach for the LDC's might appear to be an international TVA-like fertilizer technology center.

Based on the experience at the National Fertilizer Development Center of TVA, an adequate center for fertilizer technology to be established in one of the LDC's in the tropics would have to include the following basic units.

	Estimated cost million dollars
Ammonia	
Nitric acid	
Urea	
Sulfuric acid	
Phosphoric acid	
Ammonium phosphate	
Triple superphosphate	
Gypsum treatment and disposal	
Storage, handling, bagging	
Maintenance equipment, shops & service laboratories	
Spare parts	
Offsites	
Site preparation	
Total	73

In addition, major expenditures in lands, roads, fencing, housing, utilities, offices and laboratories could easily run the initial investment to $100 million. It is also estimated that to operate and maintain the basic units alone would require 130 to 140 employees with an annual budget of about $2.5 million. This still would not include the research and development staff. (The National Fertilizer Development Center of TVA has a total of over 850 employees with some 230 scientists and engineers.) Improved fertilizer materials would still have to be evaluated agronomically through existing international centers, national agricultural research centers and the fertilizer industries.

Another approach might be to take advantage of the facilities of the National Fertilizer Development Center at TVA. At the request of USAID, the TVA board of directors has indicated that land could be made available for a separately financed and operated center adjacent to the National Fertilizer Development Center. TVA would agree to furnish the "building blocks" materials, ammonia, phosphoric acid, nitric acid, sulfuric acid, etc.; permit tie-in to utilities; use of repair, maintenance, and service facilities; share the library; in some cases share the use of specialized laboratories and pilot plants; and continue to provide on a contractual basis specialized expertise for research and training. This approach, rather than requiring hundreds of people, might produce outstanding results with say 30 to 35 international scientists and engineers. The complementary effects of the two staffs might in reality produce even greater results. The international staff could certainly benefit from the contact with TVA's experienced scientists and the spin off of one program to the other could be significant.

The cost of a center adjacent to TVA would be much less than starting from scratch. Probably an initial investment--primarily offices, laboratories and small-scale pilot plants--of say $3 or $4 million with an annual operating budget of $4 to $5 million would be ample to initiate and carry out a very effective program. at current costs, more like $5-6 million.

Another probable advantage of an international center that had a close link with TVA would result from the large projected U.S. investment in energy research. Much of the investment (e.g. gasification of coal) would relate to fertilizer technology and interests of the LDC's. For many countries, a more efficient gasification of coal could permit these countries to make their own ammonia at a reasonable price.

The international fertilizer development center should not attempt to solve all the problems in the field of fertilizer and production technology, and a substantial portion of investment in the "center" should be in the developing countries. For example, Brazil is developing special competence for studying the utilization of lower grade phosphate rock. Such activities should be encouraged and expanded to be shared with other countries. India, with limited petroleum reserves but extensive coal, would be a logical site for a center dedicated to the ammonia feedstock from solid fuels. Wherever possible, pilot plant work and especially demonstration scale work should be carried out in the LDC's to both provide experience for industry and materials for market development.

Over the next six or seven years, as many as 50 or 60 major fertilizer complexes will need to be constructed just to meet the increased fertilizer needs of the LDC's. These plants alone (battery limits) could cost as much as $7 or $8 billion. Thus, it would seem that the investment of a few million dollars in research and development aimed at the needs of the LDC's, especially tropical agriculture, could be well justified. One breakthrough that would increase fertilizer use efficiency in the LDC's by 15% to 20% would pay for this investment many times over. Potential breakthroughs should greatly exceed this and may well be comparable to the high-yielding varieties that are credited with much of the success of the so-called "green revolution" of the late 1960's.

April 11, 1974

F1

✓cc: M

May 31, 1974

Dear Dr. Pereira:

I was glad to have your letter of May 20 on fertilizer problems. As you say, the subject will come up plentifully at Centers Week: it is on the TAC agenda; the Plant Nutrient Institute proposal will come up at the CG; and the Center Directors are to report to TAC on the impact of the energy/fertilizer problems on the adoption of their technologies and on their work programs.

In a week's time, I am sending you and also your TAC and Center Director colleagues two documents which are Bank efforts to answer your question on fertilizer supply and related subjects. Both documents are made available to you in your TAC capacity. As you will note, they are not for public use. The two documents are: "Fertilizer Requirements of Developing Countries" and "Issues Relating to the Fertilizer Situation" which the Bank staff presented at a joint Bank/ADC conference last week.

I think the supply estimates, which interest you most, are as good as we can make them. On the demand side, there is perhaps an over-optimistic view of how much agricultural production (and therefore fertilizer use) will increase in India. Also, the report uses the FAO's Indicative World Plan growth rates which are also subject to discussion.

With best wishes,

Sincerely yours,

Bruce M. Cheek

Dr. H. C. Pereira
Chief Scientist
Ministry of Agriculture, Fisheries
and Food
10 Whitehall Place
London, S.W. 1
England

cc: Sir John Crawford
Mr. G. Donaldson

BMC:mcj

BHC
Harlan HG
CJ

May 24, 1974

M

Mr. Graves: World Bank

Dear Harold:

Per our luncheon discussion on May 22, enclosed are a summary of the notion we have suggested for TAC consideration and a letter on the same subject that I've just sent to Warren Baum.

Best regards.

Joel

Enclosures

International Plant
Nutrition Institute

Crawford.

Outline of Proposed International Plant Nutrition Institute

The purpose is to develop improved technologies and systems for nutrition of the principal LDC crops. Special attention would be given to the needs of small farmers, and therefore to systems that involve the lowest feasible on-farm capital inputs.

Achieving this purpose is critical for acceleration of LDC food output. The latter depends primarily on higher yields per acre, rather than on farming more acres which has been the primary basis for past production increases. Higher yields depend, in turn, on increasing the absorption of key nutrients by the major LDC crops.

To further this purpose, three principal areas of research are contemplated. The bits and pieces of research already done in these areas suggest a good prospect of large pay-offs from a more intensive and well integrated effort, geared to the typical tropical and sub-tropical conditions of LDCs and their other environmental factors and disciplined to focus its efforts sharply on achieving well defined product or process results.

(1) Means to control and increase microbial action that causes biological transfer of nitrogen to plants and soil and that makes nutrients in the soil more soluble and therefore absorbable by plants.

(2) Conservation and reuse of the plant nutrients contained in wastes and in the soil, for example:

- -- reuse of nutrients from animal and human manures, urban sewage and garbage, crop residues, and industrial wastes, especially from food processing;
- -- more efficient use of nutrients available in the soil by such means as plant breeding to maximize the important role of root systems;
- -- conserving nutrients by improving a wide variety of agronomic practices such as tillage, multiple cropping, rotation and methods of applying fertilizer.

(3) Improvement of chemical fertilizers, particularly for efficiency under tropical and sub-tropical conditions, and of the technology for producing and marketing them. [This is TVA's forte, and we envisage locating a component of the Institute alongside TVA with access to its facilities and staff. A promising start has already been made on this line of research at TVA, under AID research contracts.]

An institutional arrangement that facilitates overall planning for and interaction among these research areas would increase the productivity of the total effort. Interactive concerns among the alternative lines of research include the comparative economics and social fit of alternative means or combinations of means of increasing plant nutrition in particular types of LDC circumstances, and the research and application priorities that follow from this. The need for integrated research programming and execution also reflects overlaps and complementarities among the various lines of research, e.g., between solubility research under (1) and research under (3), or between research under (1) and (2). The likelihood of achieving the interdisciplinary and inter-project collaboration needed to attain high output and efficiency is much greater within a single organization. Existing crop oriented institutes are not and could not be equipped to carry out efficiently a program of the type envisaged, although they should play a cooperative role in the agronomic work.

The structure of the Institute may have several components in different locations in addition to working linkages with many other organizations. As now envisaged, the central facility would be in a LDC.

It would:

-- plan and manage the overall research program;

-- do considerable parts of the research in areas (1) and (2);

-- arrange for other parts to be done elsewhere, as described below;

-- conduct training, mainly for LDC scientists and extension managers;

-- provide information management for the whole system.

Most of the work should be done on LDC soil to get access to a wide variety of the pertinent farm environments, to increase LDC support and use, and to facilitate non-U.S. financing.

Agronomic trials and experimentation could be carried out through a network of cooperating international and other research centers providing comprehensive ecological coverage. Basic lab/greenhouse or other basic research supporting work in areas (1) and (2) could be sub-contracted or otherwise arranged with advanced research organizations in the developed countries or elsewhere.

AA/TA
5/24/74

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

ASSISTANT
ADMINISTRATOR

May 24, 1974

Mr. Warren C. Baum
Vice President, Projects Staff
World Bank
1818 H Street, N.W.
Washington, D. C. 20433

Dear Warren:

Enclosed is a summary of the idea for an International Plant Nutrition Institute that I put informally to Sir John and a few others that Monty assembled at his office a few weeks ago.

You may have seen already the fuller paper that was quickly drawn by our agriculture staff to spell out more the types of research contemplated.

We believe that the line of effort contemplated addresses what probably is by far the most important technological bottleneck to accelerating LDC agricultural production. Given the current worldwide development priority for food supply, reflected in preparations for the World Food Conference, this direction of effort deserves very serious attention and, we feel, strong support by the Bank -- without prejudice to conclusions on the most efficient way to tackle the problem. The latter question will of course require very careful study under TAC auspices and by the interested CGIAR members.

In comparing the magnitudes at stake here on the side of world food supply and of the huge investments being made in expansion of LDC production (including the Bank's investments), with the possible costs of a major new research initiative, we believe it would be very foolish to allow concerns about the total size of the CGIAR budget to influence consideration of what can be done productively and efficiently on this particular set of problems.

I'd be happy to discuss this with you, if you'd like, at some convenient time.

Sincerely yours,

Joel

Joel Bernstein

Attachment

Discussion Draft
May 20, 1974.

M

ISSUES RELATING TO THE FERTILIZER SITUATION

ADC/IBRD Fertilizer Seminar, Princeton,

May 23-25, 1974.

G.F. Donaldson

Agriculture & Rural Development Department

I.B.R.D.

INTRODUCTION

1. First, it should be noted that the "energy crisis" is not a major cause of the recent shortage and price effects for fertilizer, though it has exacerbated them in some degree, especially in some countries. The nature of these effects in less developed countries (LDCs) in particular are discussed later.

2. Second, there has not been a decline in annual world fertilizer production of either nitrogen, phosphate or potash at any time in the past 15 years, and presumably for much longer than that (see Table 1). Further, there are only one or two instances where production in any one country has declined.

3. Third, there is no evidence that the current very high short-run demand for fertilizer is of a self-sustaining character (or a portent of things to come) due to a "population explosion", a "green revolution" or anything else of a cataclysmic nature.

4. On the other hand, everything points to the current fertilizer deficit being primarily demand related, reinforced by a reduced rate of growth in fertilizer production capacity in the immediate past, and various constraints on the manufacturing side which have prevented a rapid supply response. A confluence of events can be traced which have determined the nature of the shift on both the demand and supply sides. These seem likely to disappear as rapidly as they appeared, though there may be some lasting effects on both the industry and agriculture.

NATURE OF THE CURRENT SITUATION

5. The full implications of the current shortage of fertilizers have yet to be reliably assessed. As yet, the patterns of future prices for

nitrogen and phosphate fertilizer are still difficult to predict with any accuracy. Similarly, the agricultural impact of the supply shortfall has yet to be evaluated in any depth. However, the nature of the prevailing fertilizer situation is now sufficiently recognizable that some analysis can be made of the direction and orders of magnitude of the related changes and of the issues that arise in relation to it.

6. The current shortage and price increases relate to all main plant nutrients - phosphates (P), potash (K) and nitrogen (N). The problem is least serious for potash since lower amounts are used in crop production, the supply short-fall is less acute (being due mainly to transportation bottlenecks), and additional supplies are coming available quickly. The problem is also less serious for phosphate in that (like potash production) it is not directly affected by the crude oil shortage, and new production capacity is under construction - and because a reduced application of phosphate to crops for a season or so will have relatively small effects on yields from most crops (phosphate is stored in the soil whereas nitrogen is readily lost to the air or leached).

7. The major concern relates to nitrogen fertilizer. It is on HYV crop responses to nitrogen that the "green revolution" is predominantly based. Consequently, constraints on supplies and increased prices have far-reaching implications for the agriculture of many developing countries, and especially for food supplies. The major sources of nitrogen are oil- or natural gas-based processes for which feedstock supplies are short. Since the same feedstocks are used in the production of many crop protection chemicals, the problem is compounded - such inputs being also a feature of modern crop production technology.

Demand Related Effects

8. Since the demand for fertilizer is a derived demand, it is to be expected that a major shift of the kind we have experienced will be underlain by changes in the demand for crop products, especially cereals. Several factors have influenced this change. First, there is a long-term upward trend caused by (i) growing population, (ii) increases in incomes, and (iii) changes in consumption patterns.

9. The growth in population is the most stable factor affecting the increased growth in demand for food, especially cereals. This is presumably causing an overall increase in aggregate demand for food of some two percent per year, although in some countries it is greater and in others smaller due to differences in rates of population growth. Significantly, the higher rates of growth are in countries that are fertilizer deficient, and hence importers (mainly LDCs). The demand from this source is reinforced by the fact that the HYV technology, which is the primary means of increasing domestic food supplies in the LDCs, is highly fertilizer dependent.

10. Added to this is the increase in demand for food associated with the growth in incomes. Incomes increased substantially in many countries through the sixties, especially in the U.S., Western Europe and Japan, but also in Eastern Europe and some other countries. Although the direct effects of rising incomes on food prices are usually small, due to the relatively low income-elasticity of demand for food, there was perhaps some small increase in demand due to income effects.

11. The exception to the low income-elasticity for food argument occurs when people trade-up to superior goods, especially increasing their consumption of meat. This shift can cause a disproportionate increase in the demand for

grains - one pound of meat requires some four pounds of grain to produce. Although meat consumption has grown only some 2-3 percent annually over recent years, a fairly small rate of expansion, this has added to the demand for foodgrains.

12. Despite the steady upward pressure on fertilizer demand from this long-term trend there is nothing here to explain the recent surge in demand. However, there have been a series of abnormal effects on the demand for and production of foodgrains including: (i) a run-down of world grain stocks, (ii) widespread crop failures, (iii) sudden changes in the patterns of trade in foodgrains, and (iv) a sudden acreage expansion encouraged by government action in the major grain exporting countries.

13. A seemingly deliberate run-down in world stocks of foodgrains, mostly held in Western countries, is perhaps the most significant factor underlying the current situation. The acreage of wheat grown in the U.S. in 1970 was 80 percent of that in 1968 and 74 percent of the 1967 acreage, and the lowest since 1948 (see Table 2). In the U.S. some 60 million acres of cropland were held out of production through 1970-72 - nearly 20 percent of the total arable area. Similarly, due to acreage restrictions, Canada's wheat acreage in 1970 was only half the 1969 acreage and Australia's acreage was cut to 60 percent of its 1968 acreage. The effect of these acreage constraints was to cut the level of stocks held in those countries substantially.

14. Reinforcing this shift, there were widespread crop failures in 1972 which resulted in many countries, notably India and other Asian countries, importing more foodgrains than they would otherwise have done. As a consequence there was a severe shortage of wheat in 1972, to the extent that the FAO reported stocks at the end of 1972 to be at "dangerously low levels".

15. On top of this, the USSR entered the market in early 1973, buying 12 million tons of wheat from the U.S. alone. This turned the tight supply situation into a severe shortage.

16. Somewhat belatedly, in response to this not entirely unforseeable situation, the major exporting countries in 1973 raised quotas, released "set-aside" land and encouraged widespread cereal planting. Acreages in the main exporting countries rose by more than 10 percent in 1973 and are expected to be up by a similar proportion in 1974. The demand for fertilizer expanded equally suddenly.

17. Further, since fertilizer is also used on non-cereal crops, there are derived demand effects relating to changes in their production. In this category there were also several influences: (i) an upsurge in demand for industrial crops, (ii) a steep rise in the price of soybean, and (iii) diversion of some urea to livestock feed.

18. The economic resurgence in all Western countries that caused an increased demand and resulting higher prices for all basic commodities, also caused an increase in demand for industrial crops. The prices of oilcrops, coarse fibres, cotton and rubber, all increased in the early 1970s, some by fantastic amounts (see Table 3).

19. This was accompanied in 1973 by the sudden disappearance of the already depleted stock of anchovy off the coast of Peru - the major source of fishmeal used in livestock feeds. This had two effects. First, there was a significant demand increase for soybean meal as an alternative, and prices rose fourfold encouraging extra planting. Second, urea (otherwise used for fertilizer) was used as a protein substitute in feedmixes. Thus,

this capricious event caused a double demand effect on the fertilizer industry. (The anchovy have since returned - at least for the time being!)

Supply Related Effects

20. The supply of fertilizer has not been subject to variations of the same magnitude as demand. However, it has still been subject to a series of interacting events which have resulted in both a slower rate of output growth in some recent years (see Table 1) and (perhaps more importantly) in a number of constraints upon the ability of the industry to respond quickly to the changing demand situation. These events were related to the changing structure of the industry, economic and policy changes, distribution effects, and some other fortuitous events.

21. The supply situation has been influenced by some fairly significant structural changes (as discussed elsewhere, see "Fertilizer Requirements of Developing Countries"). These include: (i) a changing pattern of ownership, especially in the U.S., (ii) changing technology and scale advantages leading to larger plants, (iii) the disposal of inefficient plants, and (iv) some changes in the location of manufacture.

22. The changing pattern of ownership was largely a response by oil and gas firms who sought an outlet for their gas supplies through fertilizer. Some of these bought existing manufacturers but in most cases they started from scratch (or expanded) by building new plants. The emergence of these new large suppliers contributed to the surplus situation in the second part of the sixties. At the end of the sixties many of these plants were sold off to agricultural cooperatives and established fertilizer companies, though

some remained in the hands of oil and gas corporations. It is possible that such firms found profitable alternative uses for their feedstocks in recent times.

23. Some major changes in processing technology in the sixties lead to a new generation of fertilizer plants where there were considerable economies of scale. This lead to some of the 60-odd manufacturers in the U.S. becoming giants in the field. It also meant that there was a considerable increase in the "lumpiness" of capital investment in production capacity. This may be a significant determinant of the investment cycle characteristics in the future.

24. This modern plant made smaller plants of an earlier vintage relatively expensive to run, and lead to their early retirement when the market proved inadequate to maintain them profitably - no doubt to the chagrin of managers in 1973-74.

25. With the installation of new plants there was some shift in location within the U.S. and Europe, away from the former coal and steel centers toward the ports and fuel sources. In a global context there was also some growth of production capacity in LDCs - both in the oil and gas producing countries (e.g., Venezuela and Persian Gulf) and in the consuming countries (e.g., India).

26. While it is difficult to see how these adjustments could have contributed to a supply deficit in any major way, it is perhaps important that they caused a dynamic situation of change and uncertainty within the manufacturing industry which made rapid adjustment to the sudden expansion

of demand even more difficult than it was otherwise. Such a volatile situation almost certainly added to the degree of imperfect knowledge surrounding the planning and investment process.

27. Related to these structural adjustments within the industry, is an established cycle of investment in production capacity which has recurred irregularly since World War II. All evidence suggests that the recent resurgence in demand coincided with a low point in the swing of this cycle. Thus there was a delay in the supply response till new plant came on stream, and new investment was implemented. As this happened there were some inevitable teething troubles and the industry found itself with a greater demand than it could satisfy - at least in the short-run.

28. Reinforcing the structural and cyclical effects there were also many operational constraints, arising from: (i) the "energy crisis", (ii) environmental control regulations, (iii) world-wide shortages of basic raw materials and commodities, (iv) the shipping shortage, and (v) low plant capacity utilization, for various reasons.

29. The "energy crisis" contributed to some extent, especially in providing alternative demands for feedstocks and in delaying the supply of other inputs. The shortage of feedstocks is known to have lead to the closure of some plants in the LDCs and to reduced output from some plants in Japan. But it also clearly restricted any rapid expansion of output in many other situations.

30. Although the production capacity rating of most plants is fairly nominal, the introduction of environmental protection regulations caused some of the upper bounds on capacity utilization to be more constraining

than usual. Most plants in most countries have to conform to controls on emissions and on water heating. These also restricted an output response to higher prices.

31. Along with other industries, the fertilizer industry encountered a shortage of basic inputs, and delays in new plant deliveries, caused by scarcities associated with the concurrent peaking of the major Western economies. This not only drove up the price of basic commodities but caused shortages of steel and other metals. It also contributed in large measure to a world-wide shortage of shipping capacity - this affected both the delivery of rock phosphate and the distribution of finished fertilizers to importing countries.

32. Added to all of these factors was the low level of capacity utilization achieved in many plants. In some cases this was of an acute nature, due to teething problems in the initial operation of new plant, to the non-availability of spares and replacements, or other delays in deliveries. In other cases this problem was more chronic in character, especially in the LDCs where the level of capacity utilization is frequently around 50 percent. This is due to many factors, including poor layout, inadequate ancillary services such as power and transport, limited storage capacity, poor maintenance standards, and various bottlenecks in the logistics of the production process. Regardless of their exact nature, such capacity utilization constraints stubbornly resist short-run increases in output whatever the demand situation.

33. There was also a group of problems on the marketing and distribution side of fertilizer supply. These related to: (i) transportation, (ii) storage and stock levels, (iii) regional allocations and (iv) hoarding.

34. In addition to the shortage of international shipping tonnage, there was also a shortage of transport capacity within many countries. Rail cars were short in the U.S. and Canada - this affected both the distribution of finished fertilizer and the delivery of potash from Canada to both North American and overseas markets. India suffered a dislocation of rail services due to labor disputes and mechanical problems. The Philippines was short of coastal shipping. Many countries had similar problems which made shortages in supply even more difficult.

35. Stocks of fertilizers were very low in some countries and in many regions within countries. This was due to inadequate storage capacity in some situations, especially in areas where the HYVs were only recently introduced. In other places it followed from the need to replant crops following the poor seasons of 1972. The shortage of local stocks reinforced the supply deficiency from major distribution centers, at least in certain regions.

36. The uneven impact of the shortage was made worse by a lack of coordination in the allocation of scarce supplies, notably in the U.S.. Where several companies served one area there were cases of local surpluses and high stock levels while other localities had short supplies. The extent to which the problem was unexpected is reflected in the lack of contingency plans for this kind of allocation, and for handling many other related difficulties.

37. In addition, there was a tendency toward speculation in stocks of fertilizer. Clearly, with visibly rising prices it was profitable for

merchants at retail and wholesale levels to hold stocks for as long as possible. There are reports that such hoarding reached significant proportions in some countries. In Western countries farmers are reported to have held higher stocks than usual, probably caused by over-ordering in an uncertain supply situation.

38. Finally, there were a series of changes which especially affected supplies of fertilizer to the LDCs, including: (i) a cut-back in supplies of aid-financed fertilizer from the U.S., (ii) the removal of price controls on fertilizer in the domestic market, and (iii) the disappearance of cheap by-products usually available from Japan.

39. In 1968 USAID spent $175 million on fertilizers for export to the LDCs, in 1971 it was less than $50 million and this year is less still. This policy change has significantly influenced supplies available to some LDCs, especially Bangladesh.

40. The price of fertilizer in the U.S. was subjected to the price control regulations instituted in 1971. Subsequent to that exports rose as the relative profitability of the export market increased. When the price constraints were removed in 1973 the rate of exports subsided as all production was diverted to the domestic market.

41. In recent years, too, there has been a technological breakthrough in the production of caprolactam in Japan. This reduced the amount of ammonium sulfate as a by-product by about half. This source of supply had been regularly drawn on by India, and has proved difficult to replace.

42. In summary, the current fertilizer supply deficit has been influenced by a confluence of events, some of which are indicated above. While listing

the active ingredients in this way does not explain the situation or resolve it, it does permit some hypotheses as to the nature of the effects and thus some insight into the related issues.

IMPLICATIONS FOR AGRICULTURE

43. That the chemical fertilizer industry is but an area of a technically advanced agriculture is frequently lost sight of. The industry exists, after all, solely because we need it as an input source in the production of food and fibre. Accordingly, the agricultural implications of the current fertilizer shortage are perhaps its most significant elements. Yet there has been little discussion of this aspect.

44. World fertilizer consumption more than doubled in the ten years to 1972, reaching almost 80 million tons (see Table 1). Usage in the LDCs grew at a lower rate than in developed countries despite the demands of the "green revolution". The LDCs consumed 14 percent of total consumption in 1972, but this is projected to rise to 26 percent by 1980. The significance of fertilizer supplies to the LDCs is reflected in the estimate that 35 to 40 percent of the incremental growth rate of agricultural output is attributable to fertilizers. With a five percent shortage of fertilizer supplies food grain production in India, for instance, could fall by more than one million tons per year. This implies substantial price increases for food (which are already evident) and higher food grain imports.

45. These effects will be accompanied by major dislocations at the farm level. For those farms which are mechanized and irrigated there will be the double effect of fuel and power price increases in addition to those for fertilizer. However, more serious might be the supply availability problem,

since this could limit irrigation and cultivation to restricted areas of crops, and lead to the use of HYVs without fertilizer, in which case they may yield less than traditional varieties. Less mechanized farms and those in rainfed areas are likely to be less seriously affected since they use less fuel and fertilizer in the first place.

Effects on Farm Costs

46. Current indications are that farmers face a threefold increase in the price for fertilizer within the year 1973/74 (see Table 3). Fertilizer and other chemicals costs ranged from zero to 40 percent of total farm costs depending on the production situation. This means that, in general, farm operating costs could rise in the short-run from zero for subsistence smallholders to as much as 100 percent for those using modern technology.

47. Clearly, the actual increase in costs will vary, first, with the level of fertilizer inputs used. Irrigated farms growing HYVs (such as those in the Punjab) are likely to be the most severely affected. The cost impact will not, however, be direct and simple, since farmers will respond to the price increases by various shifts in production patterns - changing to crops and varieties with lower fertilizer needs, using lower fertilizer dressings and substituting other inputs for fertilizer (such as green manuring). In this way the full impact of increased costs will be offset, but some loss of income may also be incurred depending on changes in product prices.

Effects on Farm Product Prices

48. Consequent upon the changes in production patterns and the related reduction in output, an increase in price for farm produce is inevitable. In

fact, as with fertilizers and most basic raw materials, there has already been a substantial increase in the past year. Price indices for major farm products on the world market are shown in Table 3. The forecast prices presented here are probably little better than a guided guess at best since they take no explicit account of the expected changes in the supply of nitrogen, and are - as always - subject to unexpected changes due to seasonal conditions.

49. A crop failure in the coming season in a country such as India, when coupled with the fertilizer and fuel supply problems, could lead to massive food shortages and further price increases. On the other hand, the increased acreage of crops being grown in the food exporting nations could offset the upward pressure on food prices on the world market. Nevertheless, the impact on consumers is likely to be great, as suggested by the figures in Table 3. Given that food is their major item of expenditure, the urban poor will undoubtedly be the most severely affected.

50. On a priori grounds, the market price for cotton, coarse fibres and rubber is also likely to rise. However, cotton acreage may decline and output be reduced in response to the fertilizer and chemical price effects, though jute, sisal and rubber will feel little effect in this regard. Since all fibres and rubber have synthetic substitutes derived from petro-chemicals for which future prices will rise, however, it is therefore expected that the price for these natural products will rise. The prospects for rubber are complicated by possible changes in the motor industry in Western countries; a reduced mileage will reduce tyre replacements, smaller cars use small tyres and less rubber. However, it is predicted that as the price of isomer

rubber rises with the higher price for feedstocks, that of natural rubber will follow it. All fibres including cotton, wool, sisal and jute are expected to respond similarly at least to some extent - though for cotton the substitution possibilities may be greater than the others (in both production and end use) and the price rise correspondingly more sustained.

Effects on Output and Income

51. The direct effects on output will be a consequence of lower yields due to less fertilizer being applied. However, more complex shifts from existing cropping patterns to new ones will alter both the physical mix and the value of output. Generally, acreages of leguminous crops (such as beans, peas and gram) will not be cut back and may even expand. Other basic food crops, especially the one which is the traditional food crop in each area, will probably not decline either - if for no other reason than that they are needed for family subsistence, but also because food crop products will have increased in price substantially in the short-run unless held down by administered pricing. Acreages of basic food crops may even increase at the expense of fibre crops such as cotton, and other export crops.

52. Fertilizer will tend to be used, first, on the highest return crops (such as sugar in India and Pakistan) and second, on those with the lowest price elasticity of demand, since prices will rise most for these products. Where less fertilizer is used output can be expected to decline. In some cases there may be a switch back to traditional varieties that are less responsive to fertilizer. There may also be a switch away from high protein crops since, unless they are legumes, their fertilizer needs are higher than

other crops. Further changes, some of which may be contrary to these expectations, will be made in response to price movements for farm products, which will depend in turn on their relative scarcity and price elasticity of demand.

53. The most significant physical output effect could be in response to changes in the use of crop protection chemicals. While yields will decline more or less proportionally to the amounts of fertilizer used, the omitting of a disease spraying or use of a greater dilution of active ingredient than is advisable, could lead to an infestation which might virtually wipe out a crop. Failure to use appropriate sprayings by some farmers may have equally serious effects even for their neighbours who do. A shortage of such chemicals, or higher prices, since they have a relatively high elasticity of demand, could therefore have effects on output and incomes of much greater proportions than a comparable situation for fertilizers.

54. It is notable, however, that these effects are likely to be short lived - though they may be recurring. The very high commodity prices of past months have already begun to decline as the prospect of rebuilding foodgrain stocks becomes recognized and other shortages become less critical. Given the rate at which new fertilizer capacity is being established (5 to 6 million tons of additional nitrogen capacity is believed assured to come on stream in the U.S. within the next 12 months) severe shortages are likely to disappear quickly and prices to come down sharply (though they will probably be higher than in the past due to higher production costs). This does not reduce the seriousness of the short-run impact, especially in LDCs and particularly in South Asia.

KEY ISSUES RELATING TO FERTILIZER

55. The first issue must be the existing information state we find ourselves in regarding the factors affecting fertilizer supply and demand. Despite the heavy reliance we are putting our fertilizer supplies in terms of increased food production, we know very little about the prevailing situation, especially concerning investment plans, capacity being installed, existing capacity, levels of utilization or constraints on output within the industry. At this stage there exists no comprehensive independent reporting system; most analysts are dependent on journal reports and ad hoc information collection.

56. Even with existing resources, spread around various institutions, it would seem possible to survey all firms producing fertilizers in the world given a small amount of planning and coordination and a small travel budget. It is of some concern that the prevailing fertilizer situation should have been subject to so many desk studies with so little effort expended on fact finding - "never have so many depended on so little!". How can a better information system be organized?

57. The second issue involves what might be done to augment fertilizer supplies in the short-run. Although the critical fertilizer situation might be resolved relatively quickly, in the next year or two the effects are likely to be severe, especially in fertilizer importing countries such as India, Pakistan and Bangladesh.

58. A review of possible measures that might be adopted suggests that the scope for affecting short-run supplies is fairly limited. Some of the

possible areas for action include: (i) making better use of the amounts of fertilizer held at various points "in the pipeline - some 20 percent of annual consumption is tied up in this way in many countries, and for some it is much higher; and (ii) raising capacity utilization by removing operating constraints (debottlenecking) - an increase of 10-20 percent is suggested as feasible for Indian plants within two years. What else can be done?

59. The third issue concerns how far we can go using chemical fertilizers as a land augmenting input, in order to increase food supplies. In part this is an empirical question which can be answered in terms of finite fossil fuel reserves, but it involves much more complex issues of likely competing uses for feedstocks and possible further discoveries of reserves.

60. But, it also involves other questions. For instance, fertilizer is a bulky input which necessitates substantial investments in storage, handling and transport facilities, all of which are lacking in the LDCs. Recently the Philippines Government found that half of all their coastal shipping was tied up for several months in transporting fertilizers, even though levels of use are less than two kilograms perhectare. Are there not severe restraints on how far and how fast we can go with this type of technology, apart from the rate of adoption?

61. The fourth issue follows from the last, and concerns the possibility of developing alternative sources of nutrients. Research on soil fertility has been heavily oriented toward the use of chemical fertilizers. Even plant breeders are oriented to the promotion of a monocultural production based on chemical fertilizers.

62. There is some evidence, however, that research on biological nitrogen fixation might lead to a clear alternative to chemical inputs. There is the existing experience with the symbiotic Rhyobium in legumes which was developed as a cheap nitrogen source for a low cost agriculture. Recent studies suggest that bacteria in free association with plants, in the root zone, may be equally effective. A technological breakthrough at the research level has paved the way for substantial developments in this field. Can we divert research funds to this new priority area?

63. Finally, perhaps only after we have considered these issues can we explore the likely demand for chemical fertilizers in the future. Clearly we need reliable projections of demand in order to be able to organize supplies. But both supply and demand can be moulded by changes in technology and alternative means of production. So many of the underlying factors are subject to independent decisions - often in an institutional setting - that neither demand nor supply can easily be forecast. Are there ways of improving the planning process?

FERTILIZER RELATED ISSUES

A great variety of issues have been raised, by various people, as a consequence of recent experience with fertilizer supply and demand effects, some of which are summarized below. This list, despits its length, is by no means exhaustive. Clearly, too, not all of these questions are of equal importance, and certainly they cannot all be translated into feasible instruments for policy makers. This listing is presented partly as a checklist of issues, but also to indicate the extent of our lack of knowledge about an aspect of the agricultural production system upon which we are placing very heavy reliance in terms of increasing food supplies.

(a) Short-Run Adjustments

(i) Can we increase fertilizer availability in the short-run? Can intermediate stocks be reduced? Can capacity utilization be quickly increased? Do adequate incentives exist for manufacturers? Should priority be given to fertilizers in the allocation of feedstocks, energy and transport?

(ii) Can we offset shortages at the farm level? Allocations to foodcrops versus industrial crops? Reduce levels of application on all crops, whole area, or selectively? Allocations to particular regions (eg., irrigation)?

(iii) Is administrative intervention required, or should current arrangements be modified? Do cheap food policies discourage fertilizer use at higher prices? Do high tariffs on fertilizer, feedstock imports aggravate farm cost situation?

(iv) What are the returns to fertilizer use in LDCs compared to Western countries? What are the opportunity costs of fertilizing American lawns, English roses and French asparagus?

(b) Longer Run Strategies

(i) Can we rely on expanded use of chemical fertilizers to provide increased food supplies? How far (and for how long) can we go in relation to feedstocks, transport systems?

(ii) Can we rely on farming system dependent on chemical fertilizers for reliable food supplies? Risk of recurrent cycles? Dangers in possible coincidence of seasonal and industrial cycles?

(iii) Is it possible to offset cyclical movements in fertilizer prices and guard against a recurrence of crisis proportions? By what means?

(iv) Should the LDCs rely on imports or pursue self-sufficiency in the interests of conserving foreign exchange and ensuring reliable supplies?

(v) Will the LDCs be prepared to rely on imports given their recent experiences?

(vi) How did we come to be so dependent on a monocultural form of crop production based on an industrial input? Are there biases in research? Are there feasible alternatives which warrant research?

(c) Fertilizer Production

(i) Should additional capacity be located in developed countries, near feedstock sources, near to markets? What are the magnitudes of the trade-offs?

(ii) Can cheaper alternative feedstocks be found? Can flared gas be profitably used? Are there alternative means of manufacture?

(iii) Do the economies of scale of larger plants exist in LDCs? What demands do they put on logistics and management? Are there less capital-intensive means of production?

(iv) Can LDC plant capacity utilization be increased? Must it inevitably be low?

(v) What are the ancillary investments necessary to support fertilizer manufacture and distribution in LDCs? Roads? Rail? Power? Water? Shipping? Training?

(d) Agricultural Production

(i) What proportion of output is attributable to fertilizer? What is the production elasticity?

(ii) What is the response to fertilizer in terms of tons grain per ton of nutrient? Do we know enough about responses on farms, especially in the longer run? What are the production effects of a fertilizer shortage?

(iii) Since fertilizer substitutes for land in most LDCs, can we find alternative substitutions? Improved irrigation practices? Better crop husbandry (spacing, fertilizer placement, weeding)? Alternative production methods (intercropping, rotations, green manuring)?

(iv) Are there substitutes for chemical fertilizers? Unprocessed mineral sources? Usable organic materials? Biological nitrogen fixation? Microbial nutrient release?

(v) What are the ancillary costs of using chemical fertilizers (transport, storage, losses, shortages, ill-timed deliveries, field application)? What are the benefits?

(e) <u>Information and Intervention</u>

(i) Is better information desirable? Can it be obtained? What is the likely cost?

(ii) Is it desirable that investment in fertilizer production capacity be guided or regulated? Is this feasible?

(iii) What is the scope for international cooperation? Can it be achieved?

(iv) What is the nature of the supply response for different fertilizers in different situations?

(v) What are characteristics of the demand for different fertilizers in different countries?

(vi) To what extent is the industry oligopolistic? Have they made excess profits?

Table 1: World Fertilizer Production and Consumption - 1960-74

	NITROGEN				PHOSPHATE				POTASH			
	Production		Consumption		Production		Consumption		Production		Consumption	
	'000 tons	% change	'000 tons	% change	'000 tons P_2O_5	% change	'000 tons	% change	'000 tons K_2O	% change	'000 tons	% change
1960	11,000		10,100		10,740		10,580		9,600		9,040	
1961	12,000	9.1	11,300	11.9	11,130	3.6	10,990	3.9	9,670	0.7	9,370	3.7
1962	13,100	9.2	12,100	7.1	11,440	2.8	11,490	4.0	10,320	6.7	9,560	2.0
1963	14,500	10.7	13,700	13.2	12,200	6.6	12,190	6.1	10,820	4.8	10,230	7.0
1964	16,400	13.1	15,400	12.4	13,740	12.6	13,500	10.8	11,900	10.0	11,060	8.1
1965	18,600	13.4	17,000	10.4	15,260	11.1	14,710	9.0	13,370	12.4	12,070	9.1
1966	21,100	13.4	19,200	12.9	16,630	9.0	15,860	7.8	15,180	13.5	13,400	11.0
1967	24,700	17.1	24,000	25.0	18,780	12.9	17,780	12.1	16,000	5.4	14,310	6.8
1968	28,200	14.2	26,400	10.0	19,870	5.8	18,700	5.2	16,860	5.4	13,580	-5.1
1969	31,300	11.0	29,300	11.0	20,490	3.1	20,060	7.3	17,510	3.9	16,130	16.8
1970	33,300	6.4	31,600	7.9	21,260	3.8	20,740	3.4	18,430	5.3	17,020	5.5
1971	36,300	9.0	35,000	10.8	22,970	8.0	21,900	5.6	19,520	5.9	18,190	6.9
1972	38,700	6.6	37,200	6.3	24,810	8.0	23,250	6.2	21,210	8.7	19,270	5.9
1973 1/	42,200	9.0	40,200	8.1	26,130	5.3	25,820	11.1	23,700	11.7	20,320	5.5
1974 1/	45,800	8.5	44,800	11.4	28,890	10.6	27,710	7.3	24,070	1.6	21,400	5.3

1/ Estimate provided by USDA and TVA material.

Source: FAO Annual Fertilizer Review for 1960-63, 1964, 1965, 1966, 1972 for 1967-72.

Table 2: Wheat Production, Selected Countries and World Totals: 1961-73

Country	Area (million hectares)								Output (million metric tons)							
	1961-65 average	1967	1968	1969	1970	1971	1972	1973	1961-65 average	1967	1968	1969	1970	1971	1972	1973
USA	19.4	23.8	22.4	19.2	17.6	19.3	19.1	21.7	33.0	41.4	42.9	39.7	36.8	44.0	42.0	47.0
Canada	11.1	12.2	11.9	10.1	5.1	7.9	8.6	10.1	15.4	16.1	17.7	18.6	9.0	14.4	14.5	17.0
Australia	6.7	9.1	10.8	9.5	6.4	7.1	7.8	9.0	8.2	7.5	14.8	10.5	7.9	8.4	6.6	11.7
USSR		(1965-69 average) 68.2			65.2	63.1	58.5	62.5		(1965-69 average) 66.9			80.0	98.8	85.8	95.0
World Total	210.8	222.1	227.7	221.6	210.9	216.1	214.5	222.2	254.3	299.4	332.5	315.5	318.6	353.8	348.4	374.4

Note: Table compiled from statistics in FAO "Production Yearbook, 1971", revised and updated with statistics from FAO "Monthly Bulletin of Agricultural Economics and Statistics", 1973 issues, and from U.S. Department of Agriculture, "World Agricultural Production and Trade", March 1972, September 1973. The 1973 figures are preliminary.

Table 3: INDICES OF COMMODITY PRICES

(constant terms - 1972 = 100)

	Actual				Forecast							
	1967-69	1972	1973	Jan.-March 1974	1974	1975	1976	1977	1978	1979	1980	1985
Petroleum	87	100	118	331	331	331	331	331	331	331	331	331
Food												
Cocoa	145	100	168	173	164	141	150	148	130	125	118	118
Coffee	100	100	103	103	104	109	116	104	101	94	94	94
Tea	132	100	83	88	103	86	73	73	70	67	64	64
Sugar (World)	41	100	108	192	180	135	101	94	84	84	85	90
Sugar (U.S. Preferential)	104	100	92	131	145	123	122	121	122	123	123	115
Oranges/Tangerines	137	100	87	86	86	86	85	85	83	82	82	82
Lemons/Limes	122	100	100	98	98	100	98	96	96	96	96	95
Bananas	119	100	88	75	79	77	75	74	73	72	72	80
Livestock Products												
Beef	-	100	106	87	103	105	103	102	105	107	110	122
Hides and Skins	76	100	104	108	99	99	101	96	101	103	106	106
Grains												
Wheat	119	100	171	220	214	103	171	155	145	132	122	128
Rice	172	100	198	282	228	205	187	170	155	141	131	134
Maize	116	100	145	165	156	147	142	135	129	123	117	121
Grain Sorghum	112	100	138	152	149	140	132	125	118	110	104	106
Fats & Oils												
Coconut Oil	176	100	180	379	234	201	187	160	171	166	157	171
Copra	192	100	208	403	276	240	223	213	203	196	186	204
Groundnut Oil	87	100	105	177	124	107	99	96	91	88	83	91
Groundnuts	87	100	120	172	106	93	86	82	78	75	72	80
Palm Oil	110	100	141	212	146	126	117	113	107	104	98	107
Fishmeal	77	100	188	159	174	159	145	134	130	122	115	126
Soyabean Meal	102	100	170	99	86	70	73	78	86	93	104	113
Non-Food												
Cotton	102	100	137	148	135	115	125	100	100	100	100	100
Jute	120	100	80	67	69	71	72	73	73	73	73	69
Sisal	90	100	184	316	244	157	115	95	83	76	74	71
Wool	92	100	178	142	145	124	115	98	91	91	91	106
Rubber	152	100	164	204	168	148	140	140	140	140	140	132
Tobacco	123	100	86	78	78	79	80	81	82	83	84	84
Timber												
Logs (Lauan)	125	100	139	175	170	152	155	159	163	166	170	179
Logs (Niauga)	98	100	168	150	159	136	139	142	145	148	152	159
Metals & Minerals												
Copper	151	100	137	160	164	142	134	127	127	127	127	140
Lead	107	100	118	154	128	120	116	108	104	104	107	107
Tin	112	100	107	143	123	118	112	107	102	97	93	103
Zinc	93	100	187	289	255	191	168	149	139	140	140	148
Bauxite	128	100	87	88	127	139	152	164	176	176	182	182
Iron Ore	117	100	88	92	92	82	87	92	101	110	119	128
Manganese Ore	125	100	98	124	124	111	99	96	90	96	102	96
Steel	80	100	110	n.a.	111	108	105	104	101	97	94	95
Fertilizers												
Phosphate Rock	125	100	100	263	269	243	220	205	200	199	197	141
DAP	88	100	109	182	184	158	127	115	107	102	103	103
Urea	144	100	133	300	272	233	196	154	130	117	112	137
Muriate of Potash	91	100	107	115	113	98	91	90	88	87	85	77

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Our Ref: 16.1

M

P A Oram Esq
Secretary TAC
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20 May 1974

Dear Peter

As we approach another Centres Week, in which Institute Directors will report progress in both research and extension of improved agricultural techniques to the developing world, I am increasingly concerned with the supply situation for fertilisers.

We shall, in Washington, be reviewing success in a massive campaign to introduce more fertilisers into tropical subsistence agriculture, both for crops and for pastures.

At the same time, fertiliser supply is causing increasing concern in the most developed countries, where it is already essential to our standards of living. In the UK we manufacture 90% of our own ammonia for fertiliser, but we have been importing the rest from Trinidad, and have recently completed a large liquid-ammonia refrigerated terminal in the West Country for importing by large tankers.

Similarly, the USA has recently switched from exports to imports and is currently said to be short of 3m tonnes of nitrogen per annum.

I am sure that at least nitrogen supply should be on our TAC agenda, and indeed on that of the Consultative Group, for next July.

In the meantime I feel the need to be better informed for such a discussion. I am sure that FAO will have published recent reviews of the world fertiliser situation, and it is probable that IBRD will have commissioned some up-dating activities in so rapidly changing a situation.

I am not seeking a mass of statistics, but if you could let me have any convenient published summary of the supply position as seen by FAO I would be grateful. By copy of this letter I am asking Harold Graves if it is possible to let me have any current-awareness summary of the fertiliser supply position from his side of the Atlantic. I am prepared to keep any particular piece of information confidential if there is any necessity so to do.

I feel that TAC has a very real responsibility to advise the CG on how the supply position should affect our policy and thinking on R & D for the developing countries.

With kind regards

Yours sincerely

H C PEREIRA

cc Sir John Crawford
Mr Harold Graves

With greetings. Percy.

M

April 29, 1974

AN INTERNATIONAL PLANT NUTRITION INSTITUTE

Problem:

Food production in most of the LDCs will have to be doubled by the end of this century, just to maintain the present inadequate level of human nutrition. Most of the necessary increased production will have to come from increased yields from lands already in use. Undeveloped arable lands are mostly remote from centers of population and industry or are marginal. The assurance of better yields is required before these will be developed. One of the major constraints to increased yield is the lack of essential elements for plant growth in an available form. In developed countries supplementary plant nutrients are usually applied in the form of fertilizer, lime or nutrient sprays. While commercial chemicals are an important source of supplementary plant nutrients for many of the LDCs as well, there is not enough fertilizer to meet the needs of the vast areas of farming land in these countries now or in the foreseeable future; nor would there be sufficient foreign exchange to purchase the fertilizers if they were freely available. Thus the whole problem of plant nutrient supply must be looked at from many aspects. No reasonable means to overcome the plant nutrient deficit should be overlooked.

Scope of Proposal:

An International Plant Nutrition Institute (later referred to as the Institute) is proposed to focus and sustain attention on the means of supply of plant nutrients and ways of using them more efficiently. By combining a number of disciplines within a single center, neglected areas of research which have lacked a sponsoring organization can be identified and studied.

Such a center will provide a critical mass of highly motivated scientists and teachers not only to concentrate on basic research but to reduce to practice fundamental discoveries as they are reported at laboratories throughout the world. In providing essential functions such as definition of problems, analyzing, storing and dissemination of information, as well as serving as a training center for advanced scientists, it will increase the pool of skilled experts and hasten the utilization of knowledge throughout the world.

The proposed Institute would attack problems of nutrient supply by considering the overall system: interactions of plant, soil, water, fertilizers and weather. Particular attention would be given to three priority areas: 1) investigation and development of means to control and increase the biological fixation of nitrogen and microbial solubilization of soil nutrients; (both fields have received too little attention for too long, although these mechanisms provide the basic nutrient supply on which the world depends for most of its food);

2) conservation and reuse of the plant nutrients in farm and other wastes and in animal and human manure; and 3) improvement of chemical fertilizers, especially for the tropics and subtropics, and the technology to produce them.

Biological Fixation of Nitrogen and Microbial Solubilization of Soil Nutrients:

As fundamentally important as these biological processes are to agriculture, particularly in the developing countries, there is a dearth of data that can be readily utilized to improve their impact on a broad basis. While a number of valuable collections of Rhizobiaceae have been made, very little work has been done to screen them for efficiency under tropical conditions. Correspondingly, work is limited on the exploration of other symbiotic and non-symbiotic nitrogen-fixers in relation to more productive agriculture for the tropics and sub-tropics. In both cases, more attention is needed in some of the more basic aspects of biological fixation of nitrogen. As envisaged, the Institute would also be concerned with microbial solubilization of other nutrients in the soil -- phosphorous is one example. All of these microbiological approaches have the potential of developing a technology that would be "low-capital-input" in nature and thus more readily adaptable by the small farmer.

Re-utilization:

One group within the Institute will lead the work on re-utilization research. Re-utilization of nutrients in crop residues, farm and urban wastes (including manures and sewage) is an inherent part of all farming systems but like all recycling systems, it is subject to losses. Control of these losses on the farm, in the forest, factory, and from the urban community will go a long way toward meeting the nutrient needs of our crops. Conservation systems must be studied as thoroughly as systems for bringing new nutrients into plant cycles but have received much less attention to date.

Means of saving the nutrients in the leaves and stems of plants will be assessed, especially in tropical environments. An attempt will be made to maximize the role of root systems and assure efficient utilization of available nutrients. Manure and urine from the house as well as the barn contain most of the plant nutrients of the food and feed consumed. Sanitary, efficient and acceptable means will be identified or devised to return these nutrients to the fields. Towns and cities are extremely wasteful. Better means of recovering the valuable components of garbage and sewage will be sought. Similar waste and disposal problems created by the factories processing fruits, vegetables and some industrial crops may be solved in a similar way. Various means of saving plant nutrients will be studied.

Farm management schemes, minimum tillage, incorporation, multiple cropping and rotation may all conserve plant nutrients in the field. Manures can be saved and returned to the fields directly or following composting. Composting can also be utilized to concentrate and sanitize urban wastes. Anaerobic fermentation can produce useful gas from plant residues, manures and sewage. The sludge from such fermentation still contains all of the nitrogen, phosphorus, potassium and secondary and micro nutrients in the fermented organic material. Industrial processes, based on partial oxidation, perhaps coupled with steam reforming can be used to recover both nutrients and energy. Finally, although wasteful of both nitrogen and sulfur, simple burning of plant and animal wastes does not destroy phosphorus and the basic elements. The mineral nutrients can be carried back to field and reused by crops.

The problems of reuse (with present knowledge) which need to be solved are mostly related to the cost in money and energy in gathering, processing and redistributing nutrients contained in the waste. Therefore, good economic analysis must accompany technical developments to provide a basis for selection of systems suitable for use in various locations and according to the amount of material to be handled.

Fertilizer Development:

No center for plant nutrient research would be complete without active research on fertilizers. Both new products and new production technology are needed. New and old raw materials must be evaluated and better or less expensive means of converting to plant use will be sought. By their nature and cost of production, fertilizers are items of trade and understanding markets, supply and demand are critical. Law, relating to prospecting, extraction of raw materials, production controls, and process patents and licenses all either limit or control the fertilizer supply and fertilizer cost. Too often lack of information about the law discourages efforts to develop new sources of fertilizers, excludes investment, especially off-shore investment, or may lead to unwise and disastrously costly mistakes.

An International Fertilizer Development Center is an essential unit of the Institute. The cost of basic production facilities to provide the range of raw materials needed for new product development would cost approximately $100,000,000 -- six to eight times as much as the rest of the Institute. Most of this capital overhead can be avoided through establishment of a branch of the Institute at the National Fertilizer Development Center, TVA, located at Muscle Shoals, Alabama. The Board of Directors of TVA has indicated willingness to cooperate in an international effort by allotting land for offices, laboratories and other facilities. The International Center would be supported by supplying utilities, services and materials at the same costs used within TVA. As space and facilities permitted, the international scientist will also be allowed to work in the laboratories, production and pilot plants owned by TVA. The details of their offer will be presented separately.

Fertilizers will be designed to overcome soil reactions which sequester nutrients from crops, which control leaching and which can overcome difficult management problems such as precise timing or applications in dense standing crops. Cost will not be neglected. More concentrated fertilizers which minimize shipping costs will be developed. Others will be found which have superior handling or storage properties, reducing both cost and the care necessary in handling. Economical production technology will be developed for the new products and improved technology developed for the "old" fertilizers.

Multidisciplinary Approach:

To be effective the Institute must combine a number of disciplines with focus on fundamental biology, chemistry and physics which can be applied to plants, micro-organisms, fertilizers and their integration into productive farming systems. Plant scientists will need to screen existing genetic collections and, if necessary, explore centers of origin to determine genetic limits of nutrient utilization. Studies in morphology, cell biology and plant physiology will replace simple empirical selection with guided search.

Soil research will be another key supporting discipline in the Institute, and will be closely integrated with other research on tropical soils now being conducted in many parts of the world. Soil chemistry will help to assay the nutrient supply and to assess the rates of availability of the nutrients. The presence and concentration or activity of toxic or detrimental elements within the soil can also be measured and used as a guide to plant selection, microbiological adaptation and soil management practice. The physical properties of the soil and the movement, retention, and release of water within it are critical for plant growth and for understanding nutrient uptake. For example, nitrogen utilization and loss are closely related to the percolation of rainwater and capillary flow of water into the active root zone or to the surface. Fertilizer solution rates, depth of placement and dispersion of the fertilizer through the soil are all inter-related and must be considered in product and system evaluation.

Soil microbiology is one of the prime fields in its own right but it is also the link between the soil and the plant which must be known and understood if many plant responses are to be predicted. The growth and survival of Rhizobia are dependent on soil conditions as well as on the species of plants in the field. The conversion and release of nutrients from crop residues, manures and other wastes is dependent on the microbial processes. Understanding the relationships is the key to controlling unnecessary loss. The natural soil flora have strong antibiotic output and can sanitize many wastes, including human excrement.

Plant and soil interactions, including nutrient uptake, are controlled to a large extent by the weather, therefore a meteorological/climatological section is needed both to define conditions under which various crops will be grown and to select appropriate areas for search, testing and recommending final adaptation trials and introduction of a variety, a fertilizer or particular strains of micro-organisms.

Fertilizer technologists with a range of disciplinary background will be needed to develop fertilizer designed specifically for the unique requirements of tropical agriculture. All of the soil and crop and fertilizer technology disciplines must be combined in management systems to take fullest advantage of native supplies of nutrients, the potentially inexhaustible supply of nitrogen in the air and the effective use of fertilizers.

Training:

Training will be an essential element of the program of the Institute This will be coordinated by a professional staff but much, if not all, of the training will be conducted by or under the supervision of the working scientists. Training at the center will be for advanced acientists or extension leaders. There is no need foreseen to use the center for training technicians, extension agents or farmers.

Information:

The gathering and dissemination of information on plant nutrients will be a major function of the Institute. The library will be a cornerstone but there should be no attempt to duplicate the collection at TVA. Data collection, storage and retrieval is similar. TVA and FAO have already established an efficient and readily accessible system on fertilizer production, marketing and use. They are already the accepted source of such data and nothing is to be gained by duplicating the service. Publication of research at the center, satellite facilities or independent laboratories will extend the knowledge obtained, enhance the prestige of the center and its scientific staff and help to keep investigators in the field fully informed on the work of their colleagues. Production of displays and other visual media, perhaps including movies, can be undertaken directly by the information division or through a contractor.

Organization:

The organization of the Institute will reflect both the biological and technical environment around the world. The central laboratory of the Institute can be located in almost any part of the tropical world but should be close to a center of scientific activity. The central laboratory will be devoted to portions of the research and advanced training for the most part. Satellite centers will be advisable or necessary for two reasons. Since studies of the efficiency of nutrient use by plants is a study of the reaction of plants to their environment, materials, varieties and even concepts must be tried under various conditions. Not every soil or climate can be tested but sufficient variety can be sought to permit generalizations in which both the scientist and the farmer have confidence. The advantage of developing a satellite adjacent to existing facilities has been discussed. TVA is the logical example because of the very high cost of the basic building blocks from which new fertilizers can be built. Other satellites might be developed in conjunction with international centers which maintain a major germ plasm bank or a university or research center with a major collection of bacterial or mycorrhizal species and strains.

Contract research is another means by which the center can minimize capital costs while controlling the direction of research and assuring that significant results will be reported in a timely manner and widely distributed. Contracts which support graduate students can relieve the shortage of qualified microbiologists. Contract research may also be effective in creating local facilities for training. A scientist with a good record in adaptive research can often relate to extension agents and to farmers as well or better than the professional teacher who has never had the opportunity to test the ideas he is passing along.

Contract research has many other advantages. The skills of active scientists can be tapped without luring the men from the institutions in which they are established. Thus the Institute will become a supporter and not a competitor of national and especially university programs. This will have the effect of maintaining a broad base of inquiry and avoiding the myopia which could develop if all the work were done at the Institute.

Field research must be done in various locations and in a range of climates. It is not desirable to create a whole system of branch stations. It is desirable to have wide geographical and climatic coverage by using a large number of cooperators. Again funding capability will be important. Many university scientists have the interest and ability to make significant contributions but have very limited budgets to support research. This budget support will be provided.

Linkages with other institutions is the critical element in almost any complex scientific undertaking. The international institutes will be the source of much of the biological material and hopefully will cooperate in breeding desirable cultivars; further, they should be anxious to test that which is identified by the International Plant Nutrition Institute. National research centers and universities will play both roles. FAO, UNIDO, and UNDP are all sources of information and potential program exchanges. Industry cannot be ignored. The commercial seed industry, especially in the developed countries, has a scientific capability which dwarfs many of the better universities. Fertilizer manufacturers and vendors offer possibilities in testing production ideas but more importantly, in testing farmer acceptance of new products.

Estimated Cost:

Preliminary estimates for the Institute indicate about $19 million for capital facilities, and about $8 - $10 million per year for operating expenses (including an envisaged fertilizer technology component -- possibly at TVA). This component at TVA would require around $4 million in capital costs, and $2 - $2.5 million in annual operating costs.

OFFICE MEMORANDUM

DRAFT

M

TO: Mr. Montague Yudelman, AGPDR

DATE: April 26, 1974

FROM: Joris J. C. Voorhoeve, AGPDR

SUBJECT: Note on the Plant Nutrient Institute

1. The American Secretary of State recently proposed to the U.N. General Assembly "the establishment of an international fertilizer institute as part of a larger effort to focus international action on two specific areas of research: improving the effectiveness of chemical fertilizers, especially in tropical agriculture, and new methods to produce fertilizers from non-petroleum resources."1/ Subsequently, the proposal has been broadened into a suggestion for the establishment of a Plant Nutrient Institute. The purpose of the Institute appears to be fourfold:

(1) to increase total fertilizer production;

(2) to raise the effectiveness of fertilizers;

(3) to reduce the energy costs of fertilizer production;

(4) to increase the supply of organically produced plant nutrients.

The subject of increasing total fertilizer production has been dealt with at length in the World Bank's Fertilizer Policy and Program. The other three subjects are briefly discussed below.

Raising the Effectiveness of Fertilizers

2. Presently, only a part of the total fertilizer production is utilized effectively. Plant nutrients are lost in storage and transportation, particularly of urea in humid tropical conditions. Obviously, these losses can be reduced by correcting the technical and organizational flaws in national, regional, and local systems of fertilizer distribution.

3. Once applied to the soil, about 50 percent of the nitrogen disappears through leaching, gasification, or biological transformation. Potash is leached to some extent too. Particularly on acid soils, phosphates are partially transformed into insoluable salts, which may again become available to subsequent crops, however.

1/ Henry A. Kissinger, "Challenges of Interdependence," Address Before the Sixth Special Session of the United Nations General Assembly at New York, Department of State News Release, April 15, 1974, pp. 5-6.

4. The degree to which nutrients are lost after soil fertilization depends mainly on rainfall, cropping pattern, temperature, the chemical and physical nature of the fertilizer product, and the mode of fertilizer application. Losses can be reduced by using coated, slow-release fertilizer pellets, by correction of chemical soil deficiencies (e.g., pH adjustment), by improvement of soil structure through better tillage methods, by placing the fertilizer below the surface, by cover-cropping during fallow periods, and by a greater application of green and organic manures. Green manuring stumbles, however, on the problem that the water supply is generally too tight to allow for the additional cover-crops. These crops require an investment effort by the farmers that does not result in immediate and tangible effects.

5. The effectiveness of the fertilizer application can also be increased by optimal timing. At present, a lack of knowledge of exactly what the best time is, as well as delays in the supply of fertilizers to the farmers due to organizational problems and transport bottlenecks, often result in late application. To improve the situation, a large research effort is required, and agricultural extension services would have to inform the farmers about the results of this research. If the optimal timing coincides with a labor peak, mechanization may be needed to insure timely application of fertilizers.

Reduction of Energy Cost

6. Food and other agricultural products consume large quantities of energy. Most of this energy is sunlight, but modern agriculture also requires vast inputs of fossil fuels and electricity. E.g., the American farming system consumes more petroleum than any other single industry in the U.S.[1/] An energy equivalent of 748 liters of gasoline is used for the production of one hectare of corn in the United States.[2/] Most of this energy is represented by the nitrogenous fertilizers that are applied to the corn crop.

7. The largest energy-consuming input into agriculture consists of chemical fertilizers. Of all energy that goes into fertilizer production, about 87 percent is consumed by nitrogenous fertilizers, and only 5 percent by phosphatic fertilizers and 8 percent by potassic fertilizers.[3/] The approximate amount of energy consumed by the world's fertilizer industries is shown in Table 1. Most energy sources for the production of fertilizers are fossil fuels: natural gas (over 50% of all energy consumed in fertilizer production), naphtha (over 18%), coal (over 11%), fuel oil (over 4%), refinery gas (over 4%), and electricity (approximately 2%). (The remaining 11 percent is unallocated).

1/ Committee on Agriculture, House of Representatives, 92nd Congress, 1971, p. 20, as cited in: "The U.S. Fertilizer Situation and Outlook; A Report by the Task Force of the Council for Agricultural Science and Technology," January 1974, p. 10.

2/ Pimentel and others, "Food Production and the Energy Crisis," Science, 2 November 1973, p. 448.

3/ Task Force, Op. Cit., p. 9.

Table 1 Approximate Energy Input into Nitrogen and Phosphate Fertilizer Production in 1971 1/

		Developed Countries	Developing Countries	Total	Total in 10^{12} Btu's	Percentage 2/
natural gas in million NM^3	total	22500	2500	25000	883	50^+
	N	22500	2500	25000		
	P	-	-	-		
naphtha in million metric tons	total	6.65	0.75	7.5	314	18^+
	N	6.65	0.75	7.5		
	P	-	-	-		
coal in million metric tons	total	6.85	0.75	7.7	194	11^+
	N	6.85	0.75	7.7		
	P	-	-	-		
fuel oil in million metric tons	total	1.7	0.20	1.9	73	4^+
	N	1.7	0.20	1.9		
	P	-	-	-		
refinery gas in 10^{12} Kcal	total	14.5	1.6	16.1	64	4^+
	N	14.5	1.6	16.1		
	P	-	-	-		
electricity in million KWH	total	9700	1400	11100	38	2
	N	6690	1070	7760		
	P	3000	320	3320		
fuel 2/ in 10^{12} Kcal	total	47	7	54	214	11
	N	14	3.4	17.4		
	P	33	3.4	17.4		
Total		-	-	-	1780	100
	N	-	-	-		
	P	-	-	-		

1/ Excluding energy consumed for production of machinery and other capital goods, rock phosphate mining and sulphur production.

2/ The input "fuel" consists of unallocated, different fuel sources used in the conversion of ammonia and phosphatic acid to end products. Part of this consists of natural gas, part of naphtha, coal, fuel oil, and refinery gas. The exact allocation is not known. This means that the percentages of the different energy sources given in the last column are minimal; the remaining 11% should be distributed among them.

Source: R.P. Cook, "Fertilizer Production in the World From 1971 to 1980, "UNIDO/ITD. 218, tables 14, 16, 17 and 18.

8. The methods to produce fertilizers from non-petroleum products, to which Dr. Kissinger referred, include ammonia and urea production from (i) natural gas, (ii) coal, brown coal, and lignite, (iii) hydro-power, (iv) nuclear power, (v) bio-gas from garbage, manures and other organic wastes, and (vi) other potential energy sources. Each of these subjects is dealt with below.

(i) Natural Gas

9. Ammonia production clearly offers possibilities for changes to non-petroleum energy sources. Most ammonia is today already being produced from natural gas. See Table 2. Natural gas is becoming scarce and expensive in the industrialized nations; in the coming years, the cif natural gas price may move up to $1.00 - 1.50 per million Btu, parallel with the rise of crude oil. In most developing countries, however, natural gas will remain cheaper, due to the high transportation costs of gas products (liquefied gas, methanol, ammonia) to Japan, Western Europe, and the United States. Developing countries with large gas reserves in associated or unassociated form do not need to develop feedstocks other than gas and can greatly expand their ammonia industry. This applies particularly to those which flare most of their associated gas.

10. Natural gas is the most important, energy-efficient and cheapest raw material for nitrogenous fertilizers. In 1971, the world's natural gas reserves were estimated at least at 50 trillion (10^{12}) cubic metres.1/ Probably more than 14 trillion is located in OPEC countries. Net world production surpassed 1,142 billion (10^9)m^3 in 1971. About 49.8 billion (or 4.4 percent) was produced by the OPEC countries.2/ (Net equals gross minus re-injected, flared, vented, or otherwise wasted gas.) The potential net production of OPEC countries is many times higher. The reserves of the members would last, on average, 67 years if the gross production of 1972 would continue till depletion.

11. In 1972, more than 62 percent of all gas produced by OPEC members was flared, surpassing 130 billion m^3. This quantity of gas could be put to several good uses, one of which would be ammonia production for nitrogenous fertilizers. 130 billion m^3 would be enough to produce 83.4 million tons of ammonia.3/ In 1971/72, total ammonia production in LDC's was 5,801,000 metric tons of N (including Socialist Asia), which equals 7,074,390 metric tons of ammonia.4/ The volume of gas flared in the OPEC countries would enable them to increase the ammonia output of LDC's almost 12 times at very low costs.

12. The consumption of N-fertilizers by LDC's (excluding Socialist Asia) reached 5,890,000 metric tons of N in 1971/72, and the World Bank

1/ UN, Statistical Yearbook 1972, pp. 182-3.

2/ Excluding Kuwait, for which no net production figure is available. Source: OPEC, Annual Statistical Bulletin 1972, p. 11.

3/ Using 55 million scf for 1,000 metric tons of ammonia, which is a conservative estimate.

4/ Ammonia has 82% N.

Table 3: Natural Gas: Production, Utilization and Flaring, 1971 - 1972

	Reserves 1/ billion (10^9)	Production 1972 million (10^6)	Utilization 3/ 1972 million (10^6)	Flared 1972 million (10^6)	Flared as % of produced	Annually flared as % of reserves	Reserves - annual production (in years)
		(cubic meters)					
Abu Dhabi	na	11215	1038	10177	91	na	na
Algeria	4417	15529	6904	8625	56	0.2	284
Indonesia	147	na	4147	na	na	na	na
Iran	3681	41685	17757	23928	57	0.7	88
Iraq	566	7420	935	6485	87	1.1	76
Kuwait	1119	18343	6992	11351	62	1.0	61
Libya	767	14047	7813	6234	44	0.8	55
Nigeria	283	17122	273	16849	98	6.0	17
Qatar	229	5380	1103	4277	79	1.9	43
Saudi-Arabia	1918	32568	5509	27059	83	1.4	59
Venezuela	896	46020	31493	14527	32	1.6	19
Total OPEC	14023 4/	209329 5/	83964	129512 5/	62 5/	0.9 4/ 5/	67 4/ 5/
World	49900 2/	na	na	na	na	na	na

1/ Source: World Oil (Houston: Texas), as quoted in the UN Statistical Yearook, 1972, pp. 182-3.
2/ Represents the total of all countries listed in the UN Statistical Yearbook for which figures are available. Actual reserves must be much higher.
3/ Consisting of re-injection, local consumption, and export.
4/ Excl. Abu Dhabi
5/ Excl. Indonesia.

Source: Direct communications to the OPEC - Secretariat. Annual Statistical Bulletin 1972, Organization of the Petroleum Exporting Countries, Statistics Unit.

Fertilizer Study projects that the demand will reach 15,475,000 metric tons in 1980/81. The amount of ammonia necessary to meet this is 18,871,951 in 1980/81. The oil companies in the OPEC countries flared enough gas in 1972 to satisfy this future demand four and a half times. (This figure puts the present and projected fertilizer shortages in the LDC's in the proper perspective of today's energy and feedstock waste.)

Table 2: Feedstocks of Ammonia, 1971

	Ammonia in million metric tons	Percentage
natural gas	26.4	60
naphtha	8.7	20
coal	4.0	9
fuel oil	2.0	4.5
refinery gas	2.0	4.5
electrolytic hydrogen	0.9	2
Total World	44.0	100

Source: R.P. Cook, "Fertilizer Production in the World from 1971 to 1980" UNIDO/ITD. 218 dd Oct. 3, 1973, p. 5.

(ii) Coal

13. Before the Second World War, almost all ammonia was produced from coal. The investment costs of coal-based plants are much higher than those of plants using other materials. (See Table 4.) Large amounts of coal are required; maintenance and operating costs are high. Also, coal is more polluting. For these reasons, coal has fallen into disfavor, although it is more plentiful than petroleum and gas. Some developing countries have large amounts which can be delved at low cost India and South Africa, e.g., have already coal-based ammonia plants. The high present prices of naphtha and fuel oil, combined with the desire for increasing national self-reliance as well as awareness of a possible depletion of gas and oil reserves, are currently revitalizing the interest in coal. The Soviet Union plans to establish three coal-based plants in India, and the United States ordered recently six German coal-gasification plants which could be used for ammonia production (among other purposes). Use of domestic coal saves foreign currency if the alternative is importation of feedstocks, intermediates, or end products. It

creates employment and may stimulate other industrial or domestic usages of coal, where a large customer like an ammonia plant is required to achieve a minimum mine production. The same advantages are attached to lignite and brown coal, which are cheaper, but also bulkier because of high water contents, and are therefore costly to transport.

Table 4: Approximate Investment Costs of Ammonia Plants in LDC's For completion in late 1970's. Figures in millions of constant 1973 dollars.

	600 MT/D	1,000 MT/D
Feedstock		
Natural Gas	32	44
Naphtha	35	49
Heavy Oil	41	55
Coal	58	78

Including all off-sites and storage facilities.

Source: World Bank Fertilizer Policy and Program.

14. There are both well-established and new technologies for ammonia production from coal. In old processes, ammonia is made from the town gas or coke that is derived from coal. In such current processes as the Lurgi and Winkler ones, coal is gasified and ammonia is derived from syngas. A new and promising method is presently in development by Texaco. Partial oxidation of finely ground coal, in an oil slurry or simply water, replaces naphtha or fuel oil in the partial oxidation process. Partial oxidation plants using naphtha or oil could be converted to pulverized coal plants with minor alterations. In 3-5 years, this method should be ready for commercial application on a large scale, which holds a great promise for a country like India.

(iii) Hydro-Power

15. Presently, only 2% of all ammonia is produced with hydro-power or other sources of electrolytic hydrogen. In general, electricity is too expensive as compared to fossil fuels. Only where a surplus electricity capacity exists will it be economic to use power for the production of fertilizer. Fertilizer production on the basis of electricity does take place, e.g., in Peru, India, and Egypt; but, in Peru, the production costs are too high, and in India the plant concerned is being converted to fuel oil. One of the few developing countries which presently has an opportunity for expanded fertilizer production on the basis

of hydro-power is the Philippines.[1/] In general, the share of hydro-power in fertilizer production cannot be greatly expanded in an economically justifiable way.

(iv) Nuclear Power

16. Nuclear power from fusion is generally expected to become an economical energy source for wide application within a couple of years. Important safety problems have still to be solved. Nuclear power from fission, though potentially much cheaper, is still far from the stage of general applicability.

17. The electricity generated by fusion or fission can be used to produce ammonia by combining hydrogen from water electrolysis with nitrogen from the air. Phosporous fertilizers can also be produced with electricity, which would replace the sulphuric acid in the conventional process.

18. Large agro-industrial nuclear complexes have been suggested for LDCs by Edward A. Mason,[2/] but at the moment this idea does not yet seem ready for implementation. In any case, the expansion of nuclear energy generation is constrained by lead times of 7-10 years. It will probably remain an insignificant source for fertilizer production till about 1985.

(v) Bio-gas and Garbage-Fuel

19. A cheap but ignored source of methane gas, which is an excellent feedstock and fuel for ammonia and urea production, is the gas produced by fermenting garbage, cellulose, manures, and other organic wastes. Bio-gas is a natural by-product of the decomposition of cow-dung and other wastes and is being used on a limited basis to provide fuel in some Indian villages. This process reduces loss of organic matter through decomposition, preserves the organic plant nutrients, and provides up to 2,000 cu. ft. of cooking gas per metric ton of fresh cow-dung. The potential methane gas production based on the number of cows in LDC's in 1971 is at least 12.3 trillion (10^{12}) cu. ft. Experiments show that gas for cooking, irrigation pumping, and village electrification can be produced with relatively simple equipment and at low investment and processing costs (See Annex I, pp. 3-6, for the data on which these estimates are based).

1/ In the Mabuhay electrolysis plant, hydrogen by-product is presently being wasted. According to IFC, 37,000 metric tons of urea could be produced annually, at an investment cost of only 8 million dollars. See T. H. Liem, Office Memorandum to H. G. Hilton, dd, September 17, 1973.

2/ In: "An Analysis of Nuclear Agro-Industrial Complexes," Science and Technology in Developing Countries, edited by C. Nader and A.B. Zahlan (Cambridge: University Press, 1969).

20. The potential gas production from cow-dung alone, valued for instance at a low gas price of US$.10/1000 cu. ft., represents a gross value of US$1.23 billion on the basis of the 1971 dung production. In addition, the remaining sludge can be used as manure, because plant nutrient losses during fermentation are minimal. The process of capturing methane gas and simultaneously producing good fertilizer is technically feasible for certain urban composts and sludges, too. At least one plant in Great Britain is operating in this manner. This points to the possibility of combining the functions of hygenic waste disposal, organic fertilizer production, methane gas production, and recycling of salvageable materials (metals) in one and the same plant.

21. Apart from bio-gas production, waste products can be used for energy generation by simply burning them. The U.S. Environmental Protection Agency has recently estimated that 70-80 percent of the 90 million tons of home and industrial garbage annually produced in the U.S. can be burned as fuel, producing the equivalent of 150 million barrels of oil a year. As the garbage production per capita is considerably lower in LDC's, large garbage-fuel plants are not as widely applicable as in the U.S. Much waste and manure is already being burnt for cooking purposes, though the energy efficiency of household burning is low.

(vi) Other Energy Sources

22. In theory, all "alternative" energy sources can be used for fertilizer production. Shale oil and sand tar are not projected to become significant supply sources in the near future, because of technological problems, a long lead lime, and high manufacturing costs. No proposals are known for fertilizer production based on solar or geothermal energy.

Organic Plant Nutrients

23. Traditional agriculture has generally relied exclusively for its nutrient requirements on (i) manures and other decomposing organic materials, (ii) atmospheric nitrogen fixation, and (iii) nitrogen fixation by soil bacteria and other organisms. It does not seem possible or advisable to manipulate atmospheric nitrogen fixation, but organic waste products and biological nitrogen fixation are much more important potential sources for the development of agriculture in an ecologically sound and energy-economic fashion than is generally understood. Both subjects are dealt with below.

(i) Biological Nitrogen

24. The largest nitrogen "industry" in the world is of a bacterial nature, and is located in the surface soil of the earth. Azotobacter and

Rhizobia fix about 170 million metric tons of nitrogen per year.1/ For comparison, the world's industrial production of nitrogenous fertilizers reached 33 million tons of N in 1970/71. Another 10 million metric tons of nitrogen is supplied each year to the soil by the chemical effects of lightning and ultra-violet radiation, which create nitrogen compounds in the atmosphere that enter the soil dissolved in rainwater.

25. Nitrogen-fixing organisms in the top soil of arable land consist of several different types: (a) Rhizobia; and (b) Azotobacter; (c) Beijerinckia; (d) blue-green algae; and (e) other organisms. The Rhizobia invade the root systems of leguminous crops and live in symbiosis with these plants by transforming atmospheric nitrogen into nitrogen compounds that can be absorbed by the plant. The most important leguminous crops are soy beans, peanuts, chick peas, string-type beans, cow peas, and pigeon peas. The fact that these crops are so high in protein, while they require little or no nitrogen fertilizer, is entirely due to the symbiosis with Rhizobia.

26. The Azotobacter, however, are free-living bacteria, which are present in most soils. Some of these free-living bacteria develop particularly in association with certain plants. Rice, sorghum, millet, some tropical grasses, and to a lesser extent, maize, can greatly benefit from the activity of Azotobacter.

27. Blue-green algae fix nitrogen on the crust of the soil surface in humid conditions. It is also known that certain trees, such as the elm tree, have symbiotic relationships with nitrogen fixing bacteria. Bacterial nitrogen fixation even occurs in the intestines of animals and human beings, thus enabling them to subsist on minimal amounts of protein.

28. Shifting cultivation traditionally relies almost exclusively on naturally fixed nitrogen. Several tropical plants accumulate nitrogen during the fallow period. This natural fixation is mostly ignored as a source of plant nutrients. The continuous wet rice cultivation in many Southeast Asian countries is possible only because of these natural fixation, partly by blue-green algae. Very little nitrogen fixation has been found so far to occur in wheat crops.

29. The amounts of nitrogen can reach substantial levels: it has been found that grassland mixed with legumes can fix about 200 kilograms of nitrogen per ha annually. It is probable that the quantities of nitrogen fixed in tropical soils can be very high under certain conditions. There is a wide range of leguminous plants which can be used in tropical agriculture for green manure or fodder.

30. The factors that influence biological nitrogen fixation are: (1) temperature (high temperatures stimulate fixation); (2) light intensity

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1/ Ralph Hardy, as quoted in the Wall Street Journal, February 7, 1974, p. 1.

and day length; (3) soil humidity; (4) soil tillage and physical structure (one of the reasons why very little nitrogen fixation occurs in wheat may be that the soil is too open; too much oxygen inhibits the activity of the bacteria concerned); (5) the acidity of the soil (pH); (6) the amount and type of organic matter in the soil; (7) presence of phosphates (phosphorus increases nitrogen fixation);1/ (8) presence of the proper kind of bacteria. Many different Rhizobia strains exist; they are very selective and work only in symbiosis with certain crop varieties. It is therefore necessary to inoculate the seeds of leguminous crops with the proper strains of Rhizobia. One method is to grind peat mixed with bacteria and add this to the seed. (This method does not work in dry conditions.) Another method is to use brown coal with which pellets of seed and bacteria are made. In acid soils, lime pelletting of seeds can be successful; the lime neutralizes the acidity and creates a micro-environment around the seed that is favorable to the bacteria.

31. The problems of greater usage of biological nitrate fixation are that too little is known about the bacteria, the symbiosis, and the association with non-leguminous crops. Only a few scientific researchers are working on this matter: one South African, one Rhodesian, some in Australia, the U.S., Great Britain, the Philippines (IRRI), and a few in other places. It is first of all necessary to greatly expand research and to go into inoculant production. After more information has been gathered, training of researchers and extension officers will be necessary in the various developing countries. As biological nitrogen fixation varies greatly among soils, crops, and climates, future extension activities should be based on local findings. If the funds devoted to these matters would be increased greatly (presently, less than half a million dollars goes into this matter annually), it could be expected that, within a few years, important research results would be ready for farm application.

32. There are three different avenues to a greater utilization of biological nitrogen fixation: (1) manipulation of Rhizobia genes in order to duplicate the symbiosis with leguminous crops on non-leguminous crops, particularly cereals; (ii) the nitrogen producing mechanism of the various bacteria might be installed into plant cells by manipulating the genetic base of plants in order to allow them to produce protein from atmospheric nitrogen themselves; and (iii) it may prove possible to mimic the nitrogen fixation mechanism in an industrial fashion. Certain enzymes (nitrogenase) and catalytic metals could be used in the production of nitrogen from the air. It may be possible to apply this in farm-based units that would draw nitrogen from the air and convert it to ammonia. Such a system, while probably using some electricity, might greatly reduce the amount of energy required for the production of nitrogen fertilizer, and eliminate the need for import of fertilizers and transportation of fertilizers over long distances.

1/ It has recently been found, too, that certain soil fungi can infect the root system of crops and produce a mantle of fungus that assists the roots in the dissolution of phosphatic salts.

(ii) Fertilization with Waste Products

33. Organic fertilization with waste products is generally associated with "organic agriculture," which is often seen as a luxury concern of well-fed idealists in industrial countries. The subject deserves more serious consideration, however, and is more important for developing countries than is often realized. The current exorbitant fertilizer prices, the energy crisis, foreign exchange shortages, and soil erosion in developing countries are factors that justify more attention for organic manures.

34. As estimated in Annex I, the total production in LDC's of soil nutrients (N, P and K) in organic wastes that can theoretically be used in agriculture was approximately 7.8 times larger than the consumption of chemical fertilizers by LDC's in 1971. A very significant contribution to food production growth, soil conservation, sanitary and ecological objectives, energy conservation, and foreign exchange savings would be achieved if rural and urban wastes would be better utilized.

35. The value of the plant nutrients in the potential production of organic manures in the LDC's is estimated at over 16 billion dollars. (See Annex I). Most of this is wasted by dumping and incineration. In addition, organic wastes can be used to produce methane gas, without losing their value as fertilizers. As indicated in paragraphs 19 and 20, cowdung alone has a potential of about 12 trillion cubic feet of methane per year, which represents a value of at least 1 billion dollars.

36. It is true, part of these fertilizer and energy potentials cannot be captured for technical or economic reasons. But with a few exceptions, most nations neglect these potentials and do not engage in substantial research to lower costs and improve gas and nutrient recovery.

37. It is conceivable that composting and gasification remain economically not very attractive even after technical improvements, but the non-monetary values of hygienic waste-disposal, pollution control, soil conservation (and the better utilization of chemical fertilizers achieved by organic manure application) would justify government support for composting and sewage irrigation on a large scale. These are matters of collective and long-term interests that should not be left to the free market mechanism.

38. It is recommended that national governments and foreign aid donors devote more attention to this matter through research as well as technical and financial assistance. The following three tasks could be given to a new Plant Nutrient Institute, or can be executed by existing institutions. The first two tasks hardly involve much manpower or funds.

(1) An inventory study of the existing experience and research results concerning composting, sewage irrigation, bio-gas production, and ecologically responsible waste disposal in both rich and poor countries. This study should focus not only on the financial, but also on the social costs involved in the different ways of waste disposal and waste utilization, especially in overpopulated regions with high unemployment and low labor cost. The proposed study would require about 4-6 man-months.

(2) If the findings of this inventory study warrant further action (which is likely), it could be proposed to FAO, WHO, UNIDO, and the UN Environment Program to jointly issue a manual on waste disposal and organic fertilization in less developed countries. This manual could be written by about 8 experts and would require one editor. Total costs of the manual are estimated at 12 man-months, plus publishing costs of about $6,000.

Conclusion

39. The establishment of a Plant Nutrient Institute (as a new agency or merely as a body that encourages and coordinates the work of the various existing research institutions) can make a significant contribution to world food production only in the long run. Production of fertilizer from non-petroleum sources (natural gas, coal, etc.) is already under way and can be greatly expanded by the end of the 1970's. Use of gas that is presently flared is the most promising possibility, but the construction of additional capacity in LDC's requires 4-5 years. In the meantime, upgrading of existing fertilizer plants in LDC's, and import of fertilizers from the Communist and OECD countries, are the only means to increase fertilizer consumption in the LDC's.

40. The potentials of alternative energy sources like nuclear energy, bio-gas, garbage power, sand tar, shale oil, etc., are promising, but need further research. These sources cannot be expected to contribute significantly to fertilizer production before the mid-1980's.

41. The potential production of plant nutrients by biological fixation and utilization of organic wastes is very great, but here, too, a major research effort, as well as a reorientation of agricultural thinking and an enormous organizational and extension effort are required. A significant impact of organic fertilization cannot be expected before the end of the present decade.

JCVoorhoeve:nw

Attachment

Organic Fertilizers: Problems and Potential for Developing Countries 1/

Waste products from plants, animals, and humans contain plant nutrients and organic materials that are valuable to agriculture. As set forth in Background Study No. 4 of the Bank Group Fertilizer Policy and Program, the potential contribution of organic wastes to agricultural production is larger than is generally understood. The environmental costs of most contemporary methods of urban waste disposal (incineration, dumping onto land or into water) are very high.

Land, with a good crop cover, is an inexpensive and natural oxidative system for the safe disposal of the organic wastes which are left behind by most types of human, animal, and plant activity. Utilization of wastes as a means of crop fertilization has been practiced in many parts of the world for centuries. Among the most common are:

(1) Compost: The decomposition, natural or induced, of organic matter in some organized manner. The value of compost as a fertilizer depends on its composition (from agriculture: rice hulls, weeds, unused plant matter; from industry: processed food and fiber residues; other: bone-meal, fish-scrap, paper products, etc.) and the system of composting used (losses of nitrogen may easily vary from 10-60%). Farm composting efficiently combines waste disposal with soil structure amelioration and plant fertilization at low cost to the farmer. Urban composting may serve a similar purpose, but often at a higher cost, due to land and sanitation restrictions as well as the high concentration of wastes in urban areas. Mechanical composting in urban areas has the added economic benefits of the sale of salvaged metal, rags, and papers.

(2) Manures: Animal manures provide the largest single organic source of crop nutrients. Manures are readily available in rural areas, but do not contain high concentrations of N, P or K. Fresh manuring (the application of fresh manure directly to cropland) is often discouraged because of the weed seeds, worms, insect pests and other harmful organisms that may be contained in the excrement. Manures are often first rotted, a heat-producing process which destroys most of these negative aspects. An important potential of animal manures, especially cow-dung, is the production of methane gas, a natural by-product of the decomposition process.

(3) Green manures: Green manures are plant crops which are not (or only partly) harvested, and are grown to prevent nutrient leaching, to improve the soil structure, and to add organic matter to the soil. Leguminous green manures add significant quantities of N to the soil, as their root systems contain N-fixing bacteria.

(4) Night soil: Night soil (human excrement) has a somewhat higher nitrogen content than animal manures and has been used with some success especially in China, India and Japan. As with animal manures, it can be applied in its raw state, but due to problems of hygiene, it should undergo the time-consuming process of decomposition before application.

1/ This annex is an excerpt of the Bank Group Fertilizer Policy and Program Background Paper no.4.

(5) Urban sewage: Urban areas often have a great but underutilized fertilizer potential in the form of sewage, which for the most part is dumped into a nearby body of water, in treated or untreated form. Sewage has two components: the solid portion, or sludge, and the liquid portion, or sewage water. In its liquid form it can be utilized in irrigation of cropland, and in its solid form it can be processed and later utilized as a good quality fertilizer. Hygiene requires that untreated forms of sewage be used only on fodder and selected food crops such as sugarcane, wheat, or fruit orchards.

The Potential for Organic Fertilizer Production in LDC's

It would be interesting to know how large the quantities of organic fertilizers are, and what their potential value might be. Organic fertilization is often discarded by agriculturalists and economists as a romantic idea that endears only those with no concept of the total nutrient requirements of agriculture and the costs which are involved in organic fertilization. It might be, however, that a contemporary bias, caused by the high labor costs of handling wastes in industrialized nations, and a preference for clean industrial fertilizers, as well as a gross underestimation of the long-term costs of pollution and erosion, hamper objective investigation.

Any effort to pull together statistics on wastes in LDC's stumbles unfortunately on the lack of research that has been carried out on this subject. Moreover, the figures that are available may not be entirely reliable. A preliminary investigation is worthwhile, however, at least to demonstrate the quantities involved. Table 1 indicates that the total availability of organic fertilizers is very large indeed.1/

1/ This table was calculated on the basis of various publications (see bibliography), especially Organic Manures, Indian Council of Agricultural Research, Technical Bulletin No. 32, as well as FAO's Production Yearbook 1971 and IBRD's Trends in Developing Countries (1973). The LDC total for human excrement is based on the Indian calculation of 0.0047 metric tons K/person/yr., 0.0011 metric tons P_2O_5/per./yr., 0.0010 metric tons K/per./yr., multiplied by a total LDC population estimate for 1971 and 1980. Cattle estimates are based on Indian figures of 8.6 metric tons/cow/yr. excrement (liquid and solid) x number of LDC cattle (FAO Production Yearbook, 1971, p. 303) x the respective percentages of N, P and K of .0029, .0008 and .0023, likewise based on Indian findings. Assuming that cattle production will rise at least as rapidly as human population growth rates, the 1980 estimated cattle population was based on the human growth factor of 1.25. All other categories are based on a similar methodology, i.e. an extrapolation of Indian findings. As waste production increases sharply with income per capita and feed/animal, an extrapolation of Indian experiences is bound to be a conservative estimate.

TABLE 1: Total annual production of soil nutrients (N, P, K) through organic wastes in the developing world, 1971 (actual) and 1980 (estimated)*

(million metric tons of nutrients)

Source	N	P	K
Human:			
1971	12.25	2.87	2.61
1980	15.26	3.57	3.25
Cattle:			
1971	17.80	4.91	14.12
1980	22.25	6.14	17.65
Farm Compost:			
1971	9.54	3.34	9.54
1980	11.93	4.18	11.93
Urban Compost:			
1971	.48	.38	.57
1980	.60	.48	.71
Urban Sewage:			
1971	1.43	.29	.86
1980	1.79	.36	1.08
Other**			
1971	6.63	4.44	11.35
1980	8.29	5.55	14.19
TOTAL:			
1971	48.13	16.23	39.05
1980	60.12	20.28	48.81

* excludes Central America and Oceania, includes Socialist Asia.

** Bone-meal, poultry litter, bagasse, sheep/goat litter, oil cake, press-mud. (Several other sources were not included due to small potential for all developing world.)

These figures, of course, indicate only raw output. Whether the degree to which this potential could economically be harnessed to serve the world's agricultural needs is, e.g., 60 or 80%, is a matter of speculation.

Furthermore, in the case of human excrement, animal excrement, and urban sewage, our calculations for N production could be reduced by 0-50%, depending upon the assumed method of processing. (All other categories have already been adjusted to account for N losses in normal processing.)

To compare the figures of Table 1, it should be noted that the actual consumption of inorganic fertilizers in LDC's during 1970/71 was 13.2 million metric tons of N, P, and K.1/ In other words, the total production in LDC's of soil nutrients in organic manures that might theoretically be used in agriculture was about 7.8 times larger than the consumption of chemical fertilizers during 1971.

The World Bank Group has estimated that the future nitrogenous and phosphatic fertilizer consumption will be about 30 million tons of N and P in all developing countries in 1980/81 (including Socialist Asia). In Table 1 we have estimated an indigenous potential of 64.36 million metric tons of N and P in organic forms in 1971. By 1980, yearly output should be at least 80.40 million metric tons of N and P. We would anticipate, therefore, that a very significant contribution to agricultural fertilization could be made simply through an improved utilization of rural and urban wastes. Even an increase of, say, 10% of the degree to which these wastes are now utilized would be a substantial contribution to tropical agriculture.

Economic Implications

The total nutrient production by wastes, and their potential value as fertilizers, demonstrates their potential as substitutes for chemical fertilizers, whose prices are skyrocketing as a result of cyclic shortages -- which are compounded by the rise in energy costs. Table 2 indicates the value of the organic nutrient production at 1973 world prices (f.o.b) of chemical fertilizers.

1/ FAO Annual Fertilizer Review 1971, p. 36, including Socialist Asia.

TABLE 2: Value of N, P and K found in wastes of the developing world as compared to chemical fertilizers (at 1973 world f.o.b. prices)*

(in millions of US$)

	N	P	K	Total
1971	9,626	4,058	2,499	16,183
1980	12,024	5,070	3,124	20,218

* The individual farmer pays, of course, local prices, which are higher than world prices because of transport, storage, and commercial costs. He may also benefit from government subsidization of fertilizer costs, however. In Table 2, the value of N is based on the world f.o.b. price of urea (45% N) at US$70-105 metric ton, which means a price of $155-233 per ton of pure N. The average value was set at a median of US$200/metric ton. P_2O_5 value is based on triple superphosphate (48% P_2O_5) at $120 metric ton which means $250 per ton of P. The K-value is based on potassium cloride (62% K) at $40/metric ton which means $64 metric ton of K.

Economic costs of organic fertilizer production vary widely, and depend upon the processing method. We do not have sufficient data to estimate the cost of labor-intensive waste processing for fertilization. Mechanical composting costs known to us vary widely. Net production costs of a 200 long ton-per-day plant in the United States are $7.73-9.23 per long ton of processed refuse, after deduction of salvage sales. Due to a greater market for compost and a good return on salvage operations, European compost costs are a good deal lower.1/

An important source for defraying the costs of organic fertilizers is methane gas production. Methane gas is a natural by-product of the decomposition of cow-dung and other wastes and is being used on a limited

1/ Note should be made here of IFC's unsuccessful involvement in the Aevol Industrial Co. of Organic Fertilizer, S.A. (Greece). The economic difficulties of this company were primarily due to mismanagement and not inherent in the composting operation.

basis to provide fuel in some Indian villages. This process reduces loss of organic matter through decomposition, stops nitrogen loss, and provides up to 2,000 cu. ft. of cooking gas per metric ton of fresh cow-dung. This converts to a potential methane gas production of 12.3 trillion (10^{12}) cu. ft. for all developing countries in 1971, and a 15.3 trillion cu. ft. potential for 1980.1/ Experiments show that gas for cooking, irrigation pumping, and village electrification can be produced with relatively simple equipment and at low investment and processing costs.2/

TABLE 3: Manure obtained when one tonne of fresh dung is processed by (A) the traditional Indian methods and (B) through a gas-plant (fresh dung, 1,000 kg. at 0.25% nitrogen)

	Traditional method	Obtained through gas-plant
(a) Organic matter - loss by decomposition	-500 kg.	-270 kg.
(b) Nitrogen - loss by decomposition	-1.25.kg.	Nil
(c) Final manure quantity	500 kg.	730 kg.
Quality - N% on dry basis	1.0 kg.	1.37%
(d) Additional advantage	-	2,000 cu. ft. gas for cooking

Source: Garg, A.C. et. al Organic Manures (Indian Council of Agricultural Research, technical bulletin No. 32, 1971), p. 29.

1/ This figure is a conservative estimate of the theoretical potential. Research in India has shown higher quantities of bio-gas production for like amounts of cow-dung, dependent upon the material mixed with it. E.g., 300 grams of fresh dung mixed with 30 grams of cellulose produces 36 liters of bio-gas in 9 weeks. Bio-gas contains about 60% methane and 40% carbon dioxide.

2/ Benefit-cost studies will be published by A. Makhijani of the Ford Foundation's Energy Policy Project in 1974.

The potential gas production from cow-dung alone, valued for instance at a low price of US$.10/1000 cu. ft., represents a gross value of US$1.23 billion in 1971 and US$1.53 billion in 1980. In addition, gas can be produced from various other manures and garbage. The process of capturing methane gas and simultaneously producing good fertilizer has now become technically feasible for certain urban composts and sludges. At least one plant in Great Britain is operating in this manner. This points to the possibility of combining the functions of hygienic waste disposal, organic fertilizer production, methane gas production, and recycling of salvageable materials (metals) in one and the same plant.

The Agricultural and Environmental Value of Organic Fertilizers

Compost and other organic fertilizers are generally considered to be most valuable as soil conditioners and not as fertilizers.* As fertilizers, these wastes contain from 0.2-1.5% N, 0.01-3% P_2O_5, and 0.2-2% K, plus certain trace elements. Artificial fertilizers are available in concentrations many times these figures. As soil conditioners, organic fertilizers provide everything that may be lacking in the physical make-up of a soil. This is particularly important for the soils of many developing countries, which often are low in organic content, are either too acidic or too alkaline, and have been alternately baked by the sun and leached and eroded by heavy rains. In this respect, organic additives will help prevent erosion, retain humidity, adjust the pH (acidity or alkalinity), improve drainage, prevent crusting and cracking, and promote normal bacterial and animal life in the soil. Organic matter is essential to increasing the ion-exchange capacity of a soil; many tropical soils are deficient in this respect.

Organic fertilizers are most valuable when used in tandem with chemical fertilizers. Compost, manures, etc. improve the physical and chemical aspects of the soil and help maintain optimal soil conditions for sound plant growth. They provide a source of slow-release N and other nutrients, and prevent chemical fertilizer run-off or evaporation (denitrification). Therefore, organic fertilizers increase the efficiency of inorganic fertilizers, particularly in the long run.

Experimentation has shown that soil erosion and water run-off are inversely proportional to the amount of organic matter contained in the soil. (See Table 4.)

TABLE 4: Conservation effect of compost

Compost Metric Tons/ha	Total Run Off per plot (liters)	Eroded Soil Per Plot (kg.-dry wgt.)
0	102.5	30.26
200	58.3	21.25
400	3.9	0.15

Source: International Research Group on Refuse Disposal, Information Bulletin Nos. 13-20, 1969, p. 39.

Erosion is a serious problem in developing countries especially because of the minimal depth of the topsoil and the silting of irrigation ditches. Soil conservation is necessary to prevent the loss of fertile soil, the breakdown of irrigation systems, and the retention of the capacity to meet the increasing demand for food and other agricultural products.

In the past, most developed and developing countries have organized their waste disposal by way of low-cost and least-effort methods - primarily dumping untreated wastes on vacant land and in neighboring bodies of water, or incineration. Waste dumping leads to the breeding of flies, parasites, and various infectious agents. Wholesale diverting of sewage into large bodies of water severely limits the normal development of aquatic plant and animal life through consumption of the available oxygen (eutrophication). Incineration pollutes the atmosphere and destroys the nutrient contents of waste.

Proper recycling of urban and rural wastes would greatly reduce air and water pollution and limit infectious health hazards significantly.

Problems and Possible Solutions

Despite the great value that organic fertilizers can have for crop production in the developing nations, only certain countries have utilized the potential to some degree. Most nations, both rich and poor, neglect or reject a better use of wastes. There are several reasons that explain this situation.

(a) Lack of acceptance by the farmer:

With developed countries leading the way since the mid-50's, global interest in use of organic fertilizers has waned considerably. Especially in comparison with chemical fertilizers, organic materials have fallen in disfavor in modern industrialized agriculture. They are bulkier, less easily transported, poorer in nutrients (especially N), and may be labor-intensive -- depending on the processing and application methods. The lower labor costs and generally poor soil structure in developing countries wholly or partly offsets these disadvantages, however. Rural education and extension work should develop more interest in organic fertilizers. Costs and benefits to the farmer should be clearly indicated. Independent production of bio-gas for domestic use as a by-product of manuring may promote greater acceptance of organic fertilization in rural areas.

(b) Resistance in urban areas:

Urban areas in India have displayed some resistance to the utilization of urban wastes. Difficulties arise out of (1) a lack of interest by the municipal authorities -- resulting largely from their inability to meet composting expenses; (2) inadequate physical infrastructure for the removal of city wastes, and organizational deficiencies, plus lack of cheap transportation to areas of cultivation after processing; (3) a lack of sufficient demand for compost, etc. in large cities that have little surrounding farmland. Most of these objections center around the issue of financing; there is simply not enough domestic capital to establish efficient disposal schemes. Foreign donors of financial or technical aid seldom show any interest in the subject of waste disposal.

(c) Public health problems:

Working with wastes can lead to a series of health problems: fly and rat breeding, certain diseases, parasites, and noxious odors. Untreated wastes are in particular a great health hazard, to the extent that they are uncontrolled and unsterilized. Composting is one effective way of reducing the problem. Fly breeding can be controlled in compost by systematic turning of the compost in the 6th and 12th weeks of decomposition. Odors, rats, and parasite problems can be reduced by heaping wastes under controlled conditions and in areas that are removed from population centers. The Dutch experience shows that transport costs need not be a problem. Mechanical composting is sanitary, odorless, faster than conventional methods, and provides good quality compost.

(d) Economic return:

Based on findings in industrial countries, the economic return on organic fertilizers, especially as compared to chemical fertilizers, has been poor. Concentrated chemical fertilizers are more efficient and less expensive than their organic counterparts. Composting plants in developed countries and especially the United States have not found the necessary markets for processed compost, and have had to rely on subsidization. The rapid rise in the costs of chemical fertilizers (100-300% since 1969) is likely to increase the profitability of organic manures, particularly now that soaring energy costs are likely to further increase fertilizer prices. The ecological advantages of waste utilization for agriculture should not be forgotten, too. The need for effective pollution and waste controls have re-kindled interest in organic fertilizers. Aside from increased agricultural production, these sanitary, environmental, and soil conservation factors have to be taken into account when calculating the total economic return. A comparison with chemical fertilizers understates the true value. Important to the developing world are also the foreign exchange savings that result from a greater utilization of domestic resources which reduces the need to import chemical fertilizers.

(e) Lack of research in LDC's:

With the exception of India, research on organic fertilizers and proper waste disposal in the developing world is the major obstacle to a better utilization of the potential. Comprehensive analysis which stresses coordinated agricultural, environmental and public health planning is needed. Cost-benefit studies should be carried out which include all benefits and costs, in order to form a better idea of the true value of organic manures. It might also be possible to reduce capital needs of composting and bio-gas plants, and generate more employment. Admittedly, this is no easy task, as various health hazards and resistance to menial work will have to be overcome, both among workers and researchers.

M

Form No. 27
(3-70)

INTERNATIONAL DEVELOPMENT ASSOCIATION	INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT	INTERNATIONAL FINANCE CORPORATION

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MELBAVE
CANBERRA

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COUNTRY: AUSTRALIA

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Cable No.:

KISSINGER UNGA SPEECH APRIL 15 URGED ESTABLISHMENT OF INTERNATIONAL FERTILISER INSTITUTE FOCUSSING ON IMPROVING EFFECTIVENESS OF CHEMICAL FERTILISERS ESPECIALLY IN TROPICAL AGRICULTURE AND NEW METHODS TO PRODUCE FERTILISERS FROM NON-PETROLEUM RESOURCES

PARA YUDELMAN BERNSTEIN ARE ~~WRITING~~ INVITING YOURSELF HOPPER WORTMAN KELLEY AND FROSTY HILL TO ATTEND MEETING IN BANK 1700 HOURS APRIL 29 TO DISCUSS IMPLEMENTATION THIS PROPOSAL UNDER (TAC) AUSPICES REGARDS

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AUTHORIZED BY:

NAME A.A. Neylan

DEPT. Agriculture & Rural Development

SIGNATURE AANeylan
(SIGNATURE OF INDIVIDUAL AUTHORIZED TO APPROVE)

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Graves

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NAME: A.J. Meylan

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DATE: April 19, 1974

TO: SIR JOHN CRAWFORD
[illegible]
CANBERRA

CLASS OF SERVICE: LT

COUNTRY: AUSTRALIA

TEXT:

KISSINGER UNGA SPEECH APRIL 15 URGED ESTABLISHMENT OF INTERNATIONAL

FERTILIZER INSTITUTE FOCUSSING ON IMPROVING EFFECTIVENESS OF CHEMICAL

FERTILIZERS ESPECIALLY IN TROPICAL AGRICULTURE AND NEW METHODS TO PRODUCE

FERTILIZERS FROM NON-PETROLEUM RESOURCES

MAKING

PLAN ANDERSON BERNSTEIN AND/[illegible] YOURSELF HOPPER WORTMAN KELLEY AND

MOSELY WILL TO ATTEND MEETING IN PARIS 1700 HOURS APRIL 29 TO DISCUSS

IMPLEMENTATION THIS PROPOSAL UNDER FAO AUSPICES REGARDS

MEYLAN

OUTGOING WIRE

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

1818 H St., N.W. Washington, D.C. 20433 U.S.A.
Telephone (Area Code 202) 477-3592
Cable Address – INTBAFRAD

March 7, 1974

TO: Members of the Consultative Group

FROM: Executive Secretariat

SUBJECT: World Fertilizer Situation

Attached for information is the Resolution on the World Fertilizer Situation which the TAC adopted at its meeting at FAO in Rome during the week of February 4, 1974. The Resolution calls the attention of the Preparatory Committee of the World Food Conference to TAC's position on the problem.

The subject is being discussed by Center Directors at their March 4-8 meeting at CIAT, and TAC is inviting the Directors to indicate at International Centers Week in July 1974 the extent to which the shortage and high price of fertilizer and other inputs based on fossil fuels would affect the spread and effectiveness of the technology being developed and recommended by their respective institutes.

Attachment
BMC:mcj

WORLD FERTILIZER SITUATION

RESOLUTION ADOPTED BY TAC FEBRUARY 8, 1974

The Technical Advisory Committee currently meeting in Rome, February 4-8, wishes to convey to the Consultative Group the grave concern with which it views the present world fertilizer situation.

Current shortage of supply, aggravated by the resulting sharp increases in the price both of fertilizer and feed stock, will make it extremely difficult for developing countries to satisfy their normal requirements, let alone support a wider adoption of the new technologies now available.

Much of the success of the International Centres and the continuing work of this Committee is based on the development of these new agricultural technologies which are dependent on the availability and increased use of fertilizer.

While there is a continuing search for improved forms and more efficient ways of using fertilizer, fertilizer is and will remain an essential input to modern agricultural techniques. It follows that shortage of fertilizer in developing countries will not only inhibit future expansion but will push agriculture output back towards traditionally low levels of productivity.

There is the danger that many of the gains in production over recent years could be wiped out in those countries least able to afford such losses.

TAC believes that the current problems of world production and international distribution of fertilizer call for urgent consideration. Accordingly it strongly recommends that the Preparatory Committee consider placing the subject on the agenda of the forthcoming World Food Conference in November. TAC would also like to see appropriate papers prepared as part of the data papers for the Conference.

* * * * * * *

M

Mr M. Yudelman February 25, 1974

Anthony Neylan

TAC Meeting, Rome - Fertilizer

As requested by you, I informed TAC in the course of its Rome meeting, February 4-8, that work on the world fertilizer situation was going on in the Bank and conveyed your offer that the Bank would be willing to supply TAC members with the reports which emerged.

In reply, the Chairman stated that TAC was very appreciative of this offer and that members of the Committee would be pleased to receive this material under any label of confidentiality the Bank saw fit to apply.

cc: Messrs Qureshi
Graves/Cheek

ANeylan:jf AN

M

February 22, 1974

Dear Jerry:

You will recall that, at the TAC sessions which you attended in Rome earlier this month, the members discussed the fertilizer problem in the light of the energy crisis.

In closing their session, the TAC adopted a Resolution which they have asked the Secretariat to convey to the Consultative Group members. We have just received the full text and will circulate it next week. However, in view of the Center Directors' meeting on March 4 at CIAT, I thought it best to get the Resolution to you immediately as this is a major item on your agenda.

In addition, the TAC decided to ask Center Directors to indicate at International Centers Week in July the extent to which the shortage and high price of fertilizers and other inputs based on fossil fuels would affect the spread and effectiveness of the technology being developed and recommended by their respective institutes. Again, in the light of the Directors' meeting, I thought it best to put this point to you as a further input to your discussion. TAC also decided that, on the basis of Dr. Swaminathan's report, they should examine the organic approach to agriculture at their July meeting in Washington.

With best wishes,

Sincerely,

Bruce M. Cheek

Enclosure

Dr. U. J. Grant
Director General
Centro Internacional de
Agricultura Tropical
Apartado Aereo 67-13
Cali
Colombia

BMC:mcj

cc: Mr. Yudelman
Sir John Crawford
Mr. Oram

WORLD FERTILIZER SITUATION

RESOLUTION ADOPTED BY TAC FEBRUARY 8, 1974

The Technical Advisory Committee currently meeting in Rome, February 4-8, wishes to convey to the Consultative Group the grave concern with which it views the present world fertilizer situation.

Current shortage of supply, aggravated by the resulting sharp increases in the price both of fertilizer and feed stock, will make it extremely difficult for developing countries to satisfy their normal requirements, let alone support a wider adoption of the new technologies now available.

Much of the success of the International Centres and the continuing work of this Committee is based on the development of these new agricultural technologies which are dependent on the availability and increased use of fertilizer.

While there is a continuing search for improved forms and more efficient ways of using fertilizer, fertilizer is and will remain an essential input to modern agricultural techniques. It follows that shortage of fertilizer in developing countries will not only inhibit future expansion but will push agriculture output back towards traditionally low levels of productivity.

There is the danger that many of the gains in production over recent years could be wiped out in those countries least able to afford such losses.

TAC believes that the current problems of world production and international distribution of fertilizer call for urgent consideration. Accordingly it strongly recommends that the Preparatory Committee consider placing the subject on the agenda of the forthcoming World Food Conference in November. TAC would also like to see appropriate papers prepared as part of the data papers for the Conference.

* * * * * * *

H

Mr Robert S. McNamara | February 21, 1974

Anthony Neylan (Agriculture & Rural Dev. Dept)

TAC Resolution on World Fertilizer Situation

Sir John Crawford has asked me to bring to your attention the attached resolution, which he discussed with you in Australia.

Attachment

cc: Mr W.C. Baum
Mr M. Yudelman
Mr H. Graves

ANeylan:jf AN

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FOR NEYLAN AGRICULTURE DEPARTMENT TEXT OF FINAL PARAGRAPH [TAC] RESOLUTION AS FOLLOWS QUOTE TAC BELIEVES THAT THE CURRENT PROBLEMS OF WORLD PRODUCTION AND INTERNATIONAL DISTRIBUTION OF FERTILIZER CALL FOR URGENT CONSIDERATION STOP ACCORDINGLY IT STRONGLY RECOMMENDS THAT THE PREPARATORY COMMITTEE CONSIDER PLACING THE SUBJECT ON THE AGENDA OF THE FORTHCOMING WORLD FOOD CONFERENCE IN NOVEMBER STOP TAC WOULD ALSO LIKE TO SEE APPROPRIATE PAPERS PREPARED AS PART OF THE DATA PAPERS FOR THE CONFERENCE STOP UNQUOTE WILL GIVE TEXT TO YUDELMAN AS REQUESTED REGARDS =

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January 30, 1974

Mr Victor Rabinowitch
Staff Director
Board on Science and Technology
for International Development
National Academy of Science
2101 Constitution Avenue
Washington DC 20418

Dear Mr Rabinowitch,

I would like you to know how very much we appreciate the prompt assistance provided by the Academy in response to Sir John Crawford's enquiry regarding the technical feasibility for developing countries to produce fertiliser from coal.

Mrs de Leva and Mrs Risdon have kindly provided a wealth of material which I will take to Rome for next week's meeting of the Technical Advisory Committee for International Agricultural Research.

Please extend to Mrs de Leva and Mrs Risdon my warm thanks for all their help.

Kind regards,

Yours sincerely,

Anthony Neylan

cc: Dr Vietmeyer

ANeylan:jf AN

M

Mr H. Fuchs (Through Mr M. Yudelman)

January 29, 1974

Anthony Neylan

FERTILISER: Item on Agenda of TAC Meeting, February 4-8, in Rome

The subject of fertiliser will be discussed by the TAC meeting in Rome, February 4-8, under the Chairmanship of Sir John Crawford. Sir John has enquired whether the Bank wishes to refer to TAC any particular views on the whole question of research with regard to fertiliser.

I attach a note which was prepared for Sir John Crawford at short notice by Dr J.B. Allen of the CSIRO Industrial and Physical Sciences Branch. Any comments you may have would be appreciated by no later than Friday, February 1.

Enclosure

cc: Messrs Qureshi
Graves
Cheek
Fransen

ANeylan:jf