ADVANCING PAPUA NEW GUINEA'S FOOD PRODUCTION THROUGH THE USE OF INORGANIC OR MINERAL FERTILIZERS: A PERSONAL PERSPECTIVE

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ABSTRACT

Papua New Guinea has extensive inorganic, agricultural, forestry, fisheries and marine resources. About 80 % of the rural people rely on subsistence and semi-subsistence agriculture to produce food and cash crops. Many studies have established beyond doubt that there is a close relationship between fertilizer consumption and increased agricultural productivity. Applications of inorganic or mineral fertilizers have greatly increased food production in developed as well as in developing countries. With the perpetual increasing population of PNG, agricultural activities will certainly intensify which will result in the concomitant problems such as; shortages of cultivable lands, shorter fallow periods and declining soil fertility levels. To attain increased food production, the use of inorganic fertilizers and other improved agricultural technologies is unavoidable. PNG will definitely remain a subsistence level food producing country if the use of inorganic fertilizers is not encouraged and promoted.

Keywords: *Mineral fertilizers, inorganic fertilizers, organic fertilizers, agricultural production, food production, fertilizer consumption, soil fertility.*

INTRODUCTION

Papua New Guinea (PNG) compared to other developing countries, is fortunate to have extensive inorganic, agricultural, forestry, fisheries and marine resources and a generally favorable climate. Despite these favorable conditions, the agriculture sector had encountered many impediments and as such had not fared well [National Agriculture Development Plan (NADP), 2007]. The growth in agriculture is around 1% compared to the population growth of 2.7%.

About 80% of the rural people rely on subsistence and semi-subsistence agriculture to produce food and cash crops (NADP, 2007). Subsistence gardeners cultivate between 0.01 – 0.1 hectare of land while smallholder farmers, cultivate less than 5 hectares of land area. Most gardens are planted with crops for 1 or 2 years followed by fallowing; which ranges from 5 – 15 years. However, in some areas due to population pressure fallow periods have declined to less than 12 months (Hughes *et al.*, 2009). The core feature of this farming system is that land is rotated rather than crops as is the practice in most intensive agriculture systems.

In spite of the fact that in the period 1998 to 2005, production of staple foods for subsistence and sale increased faster than population growth (Bourke and Allen, 2009), with the current population growth of 2.7%, land shortages and the concomitant shorter fallow periods are likely to increase significantly.

There is a general consensus among various people that the soils are generally fertile and the rainfall is sufficient to support the cultivation of a wide range of crops, both for domestic consumption and export markets. Most of these assertions are, however, based on patriotic sentiments rather than on long-term scientific studies. For example, Allen and Bourke (2009) indicated that in relation to sweet potato production more than 70% of the total land area is of low or very low quality and that most Papua New Guineans produce food from land of moderate to low quality. Therefore, such above sentiments should be treated with some degree of caution.

There have been cases of macronutrient deficiencies reported for most of the cash crops and micronutrients deficiencies in both tree crops and food crops have been reported to be widespread (Hartemink and Bourke, 2001; Southern, 1967). Hartemink and Bourke (2001), pointed out that much of the current agronomic work in PNG is devoted to crop cultivars and entomology but very little research is conducted on nutrient manage-

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ment strategies and nutrient deficiencies. They emphasized the fact that with further intensification of land use, soil fertility will be very much affected and nutrient deficiencies are likely to increase, particularly in food crops where inorganic fertilizers are not being used.

This paper discusses the need for the use of inorganic fertilizers in food production for improved yields; and quality to support a perpetual growing population and for possible export markets. In addition, the paper may perhaps stimulate thinking on the promotion of increasing use of inorganic fertilizers in PNG.

ents essential to normal growth and development of plants. Inorganic fertilizers have become an integral part of the agricultural economy of the developed countries but their use in developing countries including PNG is a comparatively recent occurrence.

Many studies have established beyond doubt the existence of a close relationship between fertilizer consumption level and increased agricultural productivity (FAO, 1984). Crop yield levels are generally higher in those countries where fertilizer consumption levels are also high (Figure 1).

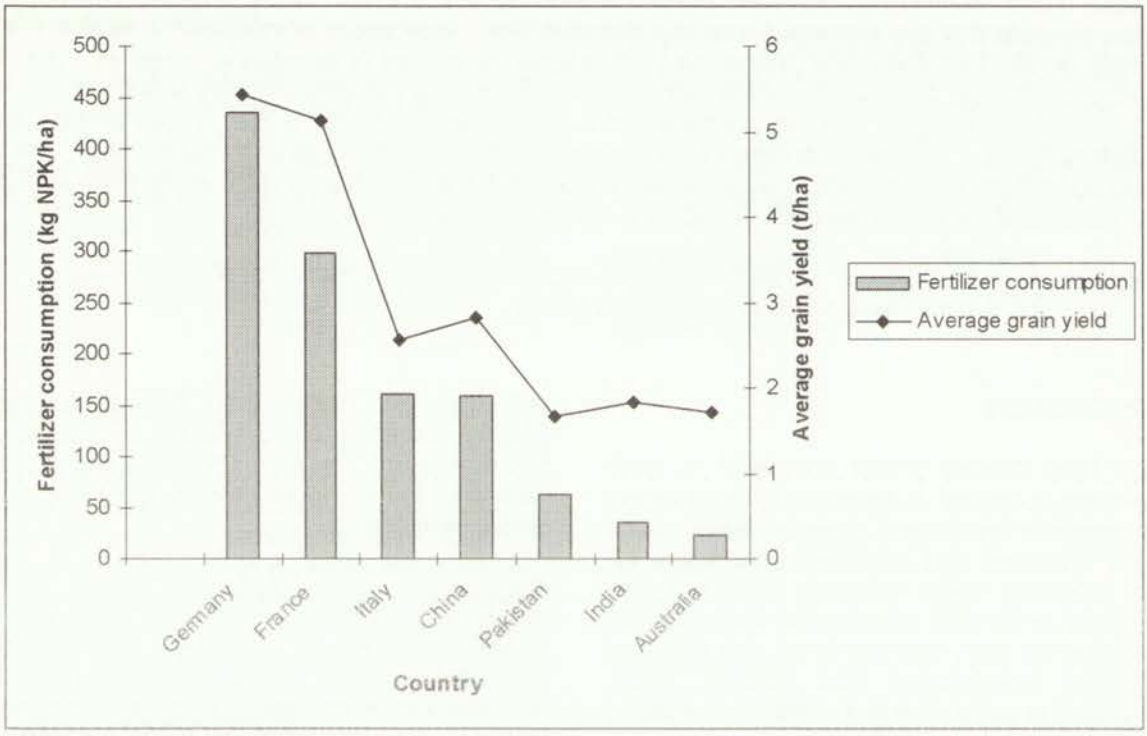

Figure 1: Fertilizer consumption and wheat yield (Adapted from FAO, 1984)

ROLE OF INORGANIC FERTILIZERS

Inorganic or mineral fertilizers are materials, either natural or manufactured containing nutri-

There is no doubt that the spectacular rise in crop yields has resulted from a combination of factors such as; crop improvement by breeding for high-yielding cultivars, improved farming methods, the use of pesticides and herbicides and last, but not the least, the application of inorganic fertilizers.

Table 1: Inorganic fertilizer consumption, yield per ha, production per head and the number of people supported by the production of 1 ha over a 180 year period in Germany. Production expressed in grain <<units>> which is equivalent to 1 t cereal grains (after Mengel and Kirkby, 1987).

Year	Number of people supported by 1 ha	Production per head, grain unit	Yield Tons/ha	Fertilizer consumption (kg NPK/ha)
1800	0.8	0.91	0.73	-
1875	1.3	0.92	1.20	3.1
1900	1.6	1.14	1.84	15.6
1925	2.1	1.09	2.28	43.9
1950	3.3	0.91	2.98	101.9
1975	4.6	0.95	4.43	233.5
1978	4.5	1.03	4.63	255.8

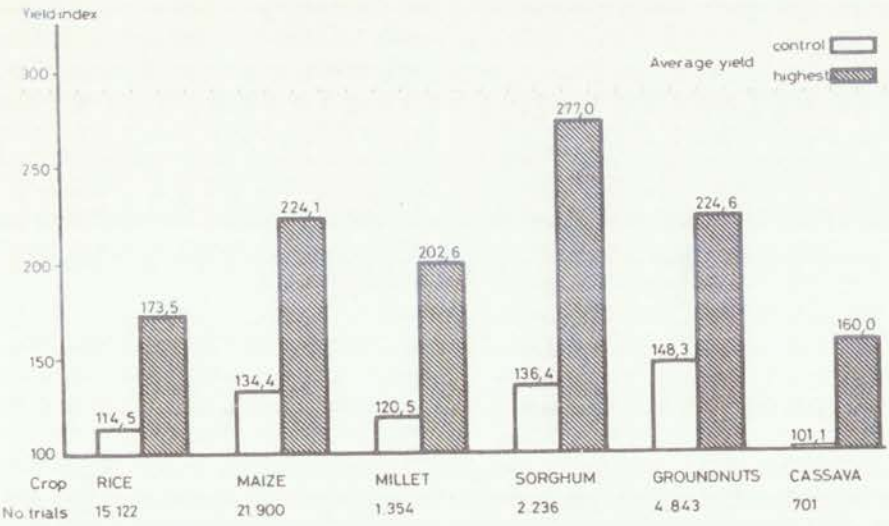

Figure 2: Crop response to fertilizers based on FAO/FP results (National average yield = 100) (Richards, 1979 from Mengel and Kirkby, 1987)

These factors are all interrelated. However, in order to establish high crop yields, adequate amounts of plant nutrients must be available in the soil.

In PNG, most soils are deficient in one or more plant nutrients and with the intensive use of farming lands, deficiencies of nutrients will certainly increase. Therefore, the differences to reach maximum potential have to be made up by inorganic fertilizer applications. The high yields of modern agriculture are thus, to a considerable extent due, to application of inorganic fertilizers. Table 1 shows the yield per hectare, fertilizer consumption as well as production per head and the number of people supported by production of 1 hectare of land. The Table clearly shows that at the beginning of the 19th century, 1 ha of farmland scarcely produced food for 1 person, however during 1978, 4.5 people could be fed from the production of 1 ha.

Amongst the various agricultural inputs, inorganic fertilizers, perhaps next to water, contribute to the maximum to increasing agricultural production. It has been estimated that about 50% of the increase in agricultural production witnessed during the last decade in developing countries is attributable to inorganic fertilizer use.

From an extensive FAO analysis of a large number of fertilizer trials conducted in developing countries, higher crop yield increases were

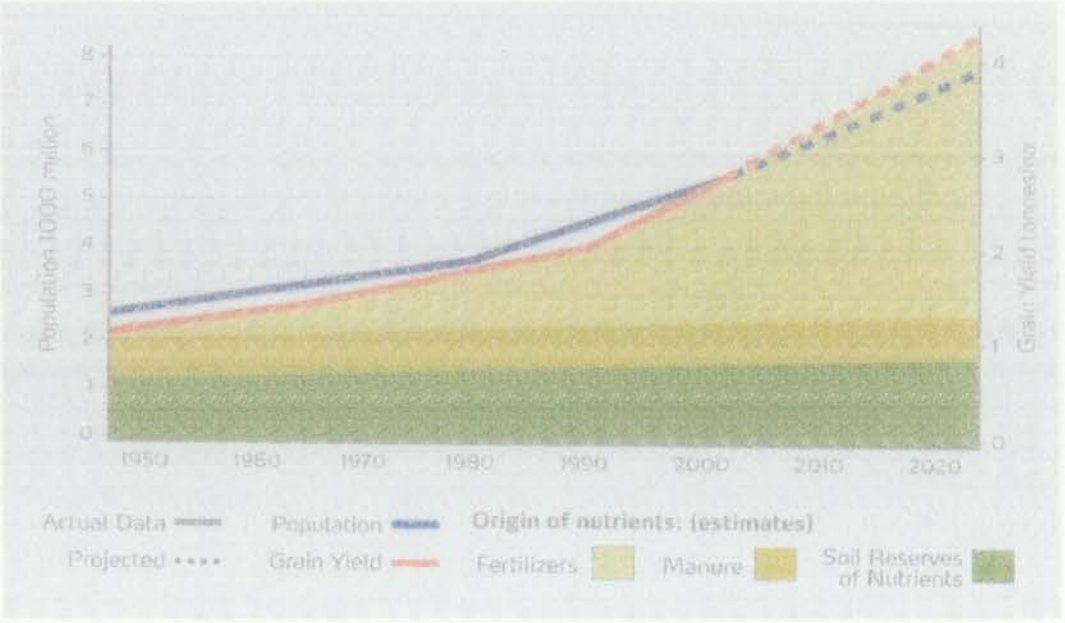

Figure 3: *Global trends in population growth, grain yield, and origin of plant nutrients (after Yara International, 2009)*

achieved as a result of inorganic fertilizer applications. (Figure 2).

Fertilizers are a key part of better farm management in improving, maintaining, or restoring soil fertility. Fertilizers promote plant and root growth which helps maintain or build organic matter in the soil. The wise use of fertilizers also prevents soil fertility decline and helps combat other forms of land degradation. Figure 3 shows the global trends in population growth, grain yield and origin of plant nutrients. It shows that whilst the soil reserve of nutrients and the use of manure are projected to remain as at present, the use of inorganic fertilizers will increase substantially and as a result, grain yield is projected to surpass the world population by 2020. While that is yet to be realized, the fact is that grain yield can not at present meet the world population's demand for grain.

FOOD PRODUCTION STATUS IN PNG

In PNG the NADP (2007) report showed that food crops including fruits, vegetables and nuts contribute 55% towards the total agriculture output. Bourke and Vlassak (2004), indicated that sweet potato dominates food production which accounts for 63.6% of the total food production output, followed by banana (9.7%), cassava (6%), yam (6%), Colocasia taro (5%), Kongkong taro (5%) and sago (1.8%). Highlighting the major differences in the structure of rural and urban diets, Gibson (2001) showed that about 65% of the rural population consume sweet potato compared to only 33% of the urban dwellers who consume sweet potato. However, 87% of the urban dwellers consume rice compared to 26% of the rural dwellers who consume rice. The same trend is also seen with wheat products.

It should be noted that the bulk of the food crops produced emanates from the subsistence and semi-subsistence producers. It is also quite apparent that food crops produced under these systems can not produce and supply food in the right quantity and quality to meet market demand. Furthermore, in the highlands there is evidence that the current indigenous soil-fertility management practices are gradually becoming unsustainable (Hughes *et. al.,* 2009) because of the increasing population pressure on gardening land areas.

In terms of grain crops production, Blakeney and Clough (2001) indicated that for rice, total production level in the year 2000 was estimated to be about 400 tonnes. Recent estimates however showed that since 2000, rice production levels from subsistence farmers have been increasing due partly to government support and partly as a result of more subsistence farmers engaging themselves in rice cultivation, that is, making more land available for rice production rather than as a result of higher yields per hectare. Average rice yields under subsistence production systems range from 1 – 1.5 t/ha. However, higher average yields of about 3–4 t/ha have been achieved when inorganic fertilizers were used (Dekuku *et al.*, 2002).

For wheat preliminary production data have shown that in the highlands region particularly in the Eastern Highlands and Enga provinces, yields of up to 2.0 t/ha had been achieved. However, with further intensive use of cultivable land and without the use of inorganic fertilizers, yields are expected to become significantly low.

Vegetables, fruits and nuts are considered as commercial food crops as they are grown primarily for sale. According to the NADP (2007) report, there are some 227,000 growers from the highlands producing and supplying between 5-6000 tonnes of fresh produce to Port Moresby markets. That is, each grower produces and supplies on average between 0.02–0.03 t of fresh produce annually which is insignificant. For PNG to attain high levels of vegetable and fruit production and to get quality products, inorganic fertilizers and other improved farming management inputs need to be used.

Bourke *et al.* (2009) showed that yields of root crops in PNG are as good as the best yields reported in other tropical locations, but they are lower compared to those of many sub-tropical locations were soil fertility is maintained by fertilizer applications and improved varieties. In addition, these authors pointed out that in some locations crop yields are very low due to population increases resulting in intensive use of land, thereby contributing to reduced soil fertility.

THE NEED FOR INORGANIC FERTLIZERS TO INCREASE FOOD PRODUCTION LEVELS FOR BOTH LOCAL CONSUMPTION AND MARKET DEMAND

Food production and supply is a competitive industry. For example, in the highlands food crops contributed 20% of the total income in 1996 and 25% in 2000 compared to coffee which contributed 33% of the total income in 1996 and 12% in 2000 (Allen *et.al.,* 2001). This scenario points out the importance of food crops sub-sector in providing relative stability in income of the rural farming households compared to those that rely mostly on export commodities, which in turn are dependent

on weather conditions and price fluctuations in the world market. Despite these encouraging trends, the fact remains that subsistence food production can not sustain the demand for food for a rapidly growing population of PNG, particularly when one considers the present high population growth rate of 2.7%.

The NADP (2007) report highlighted five major constraints contributing to low level food production. These include:

- Poor land use
- Lack of technical know-how.
- Lack of production plans and effective programs dedicated to increasing food production in the districts.
- Shortage of production inputs which include, *Interalia*, the use of very little or no fertilizers and pesticides.
- Lack of an appropriate working credit system.

The NADP (2007) report also highlighted that one of the priority program areas for development is to improve supply of production units such as improved plant crop cultivars and varieties, seeds, chemical fertilizers and pesticides for commercial food production.

It is important to point out that the introduction of improved crop cultivars and varieties will require improved or higher farm management inputs in order for these crop varieties to produce at their genetic potential. This is clearly shown in Table 2 where the application of the NPK inorganic fertilizer resulted in higher grain yield and increased nutrient uptake in an improved rice variety compared to a local variety. Since PNG is beginning to cultivate many of the introduced improved crop varieties such as rice, it is necessary that applications of inorganic fertilizers, pesticides and other

Table 2: Yield level and nutrient uptake of a local rice variety and the improved variety 1" (Kemmler, 1972).

Variety	Grain Yield	Nutrient uptake (kg/ha)		
	(t/ha)	N	P	K
Local	2.8	82	10	100
TN1	8.0	152	37	270

improved management techniques are used as well. Moreover, the nutrient content of inorganic fertilizers is known, predictable, in fixed ratios and readily available, allowing for precise delivery of nutrients to plants.

Data from long-term trials in India for rice and wheat, which are two of the most important crops that feed more than half of the world's population, show that when no fertilizer was used the grain yields were 1.75 t/ha and 0.99 t/ha for rice and wheat respectively. When inorganic NPK fertilizer was used, the yields increased significantly for both crops (Table 3).

Table 3: Yields of rice and wheat from long-term fertilizer trials in India (after Nambiar, 1994)

Fertilizer	Yield (kg/ha)	
	Rice	Wheat
No fertilizer	1.751	0.994
NPK fertilizer	3.607	3.342

FERTILIZER SUPPLY AND DISTRIBUTION

One of the strategies highlighted in the NADP (2007) report to improve supply of production inputs is to develop a cost effective procurement system for agricultural inputs like fertilizers and pesticides for commercial food production.

Procurement constitutes the first step in the entire fertilizer distribution chain. At present PNG does not have a domestic fertilizer production capability. Therefore, most of the inorganic fertilizers are imported from abroad, mostly by private companies. Often these fertilizers are stored in warehouses owned by these companies which are located in the urban centers. The movement of fertilizers from towns to the farmers' set-ups is thus non-existent. This is further exacerbated by the poor road network systems and exorbitant transport costs which make it impossible to move the fertilizers to the farmers' easy reach.

In many developing countries, the main channels of distribution are the cooperatives, private traders and state boards or other public sector agricultural agencies. These channels are absent in PNG and private traders distribute them only to the main urban centers. They do not distribute them to farmers.

For PNG to increase its level of commercial food production, the supply and distribution systems of fertilizers must be addressed and that should have been highlighted in the NADP (2007) report.

FERTILIZER QUALITY CONTROL

It is common knowledge that best results are usually obtained from the application of fertilizer only when it posses the requisite chemical composition and acceptable physical characteristics in terms of production shape, size, moisture content and storage characteristics.

The overall resource limitation of farmers in PNG and their lack of knowledge relating to the quality of fertilizer bought, makes it all the more important to have some sort of regulatory system through which quality of fertilizers can be fully guaranteed.

CREDIT

Most food crops farmers in PNG do not have the required capital to establish warehousing facilities on their own, thus demonstrating the necessity to store fertilizers at intermediate points. Therefore, dependence on external finance is unavoidable. Availability of credit to facilitate distributors' operations is necessary. There is also a greater need for credits to be made available to farmers to enable them to purchase fertilizers. The government should take an active responsibility in this regard.

FERTILIZER USE AND THE QUALITY OF THE ENVIRONMENT

Inorganic fertilizers have played a significant part in achieving higher agricultural production in both developed and developing countries. There is however a growing concern among different people with the increasing use of inorganic fertilizers and the potential side effects that could have on the environment. This is a very important subject and therefore it is necessary to look at it from different perspectives. These include looking at the fertilizer needs of modern agriculture, the relevant fertilizer-soil-plant interactions and the possible effects on human environment.

Problems from inorganic fertilizers can occur under conditions where:

- Excessive nutrient is applied than the crop requirements, either over the whole field or over part of the field especially in cases where the fertilizer might be spread unevenly.
- A deficiency in one nutrient is left uncorrected which may lead to unbalanced nutrition and poor utilization of other nutrients.
- Nutrients applied in manures are not considered when applying fertilizer.

The problems that can then occur include: leaching of nitrate into aquifers or surface waters, loss of phosphorus-enriched soil particles to surface waters that can contribute to eutrophication, and loss of ammonia or nitrogen oxides to the atmosphere by volatilization and denitrification.

However, when used correctly inorganic fertilizers can improve and protect the environment in several ways. These include:

- Improved productivity from cropped land avoid the need to destroy further areas of natural forest and grassland.
- Sustained green crop growth vital for maintenance of the atmosphere.
- Reduced losses of soil due to wind and water erosion. Small particles of soil can be easily eroded from bare areas of a farmland. Many of these particles can end up in water ways with a potential of causing pollution of surface waters. Erosion can thus be reduced by the maintenance of green crop cover with active healthy root system.
- Improved crop rooting systems which can make better use of both the soil's nutrient supply and applied fertilizers. This reduces the risk of nutrients entering ground water.
- Land reclamation and safe disposal of degradable wastes is improved by fertilizers encouraging active crop growth.
- Increased soil organic matter through incorporation of greater amounts of crop residues associated with higher crop yields.

Thus, using the correct amounts of inorganic fertilizers and applying them in right amounts to satisfy plants demand, and by taking appropriate measures to control runoffs, some of the associated environmental problems can be minimized.

ORGANIC FERTILIZER NUTRIENTS

Generally organic materials influence plant nutrient availability by:

- Providing plant nutrients, however, the nutrients content is very variable and often low.
- Providing a source of carbon and energy for microbial activities.
- Controlling net mineralization-Immobilization patterns.
- Increasing soil organic matter, which can improve soil structure, water storage and cation exchange capacity of soils.

It should be noted however that all sound farming practices such as crop rotation, the use of green manure crops, retention of crop residues and

minimum tillage can also help to maintain or improve organic matter levels, thereby contributing to soil conservation.

Although, there are examples of increased crop yields as a result of the combined application of inorganic fertilizers and organic fertilizer materials like farm yard manure, in many Asian and African countries, organic fertilizer materials such as animal manures and crop residues have competing uses and the problem therefore is one of a shortage rather than the surplus. Furthermore, the systems produce very little biomass, and much of what is produced, is consumed by grazing animals and deposited elsewhere. The return of organic matter to the soil is thus negligible.

For subsistence gardening, composting may meet some of the food requirements of a family unit. However, composting cannot meet the food demand of a fast growing population like that of PNG. Application of organic fertilizers can supply some of the plant nutrients but not in large quantities. They are simply not available in adequate amounts to meet the crops demand. In addition, they can not supply all of the 16 elements essential for healthy plant growth. In fact, most of these organic fertilizers have too many nutrient imbalances. They are also bulky hence handling and transportation are usually difficult and costly. There have been numerous examples that; of all the different components of input, inorganic fertilizer use alone has shown to rapidly and easily give higher agricultural production. No other sources of nitrogen, phosphate and potash are available in sufficient amounts to satisfy total world requirements for plant nutrients. Increasing use of inorganic fertilizers is, thus, essential to satisfy world-wide demands for food and, in this respect, PNG is no exception.

CONCLUSION

As pointed out by Hartemink and Bourke (2001), as PNG's population increases the use of land will further intensify which will result in soil fertility problems, and nutrient deficiencies are also likely to increase. PNG will certainly remain a subsistence level food producing country if the use of inorganic fertilizers is not encouraged and promoted.

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