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Grain Production Potentials In Developing Countries: World Implications

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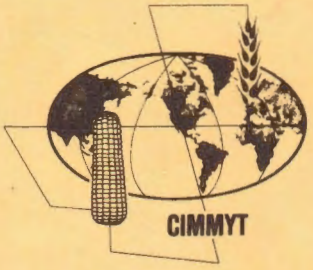

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GRAIN PRODUCTION POTENTIALS IN DEVELOPING COUNTRIES -- WORLD IMPLICATIONS

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GRAIN PRODUCTION POTENTIALS IN DEVELOPING COUNTRIES - WORLD IMPLICATIONS

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The future of food production in spite of Malthus (1) warning in 1798 has become a topic of overriding concern only in the past 12 - 15 years. There have been a number of very severe famines such as that in India 1669-1670 in which three million died; in 1846-1847 in Ireland where one third of the population was decimated; in 1877-1878 when 11 million died in North China and; in the recent past in the Sahel, Africa where at least several hundred thousand perished. Because of poor communication and a less compassionate view, all but the last of these were taken in their stride by people of other countries. The easy food situation of the post World War II era also lulled many into complacency but 1972 brought on a full realization of the precarious position in which the human race now finds itself. Disaster was averted but could it be averted in the future as population pressures begin to mount? The future looks dim in some respects but there are significant areas of hope as well if we have the will to buy a continued grace period in which population control must be sought by all means. The time for demagoguery on population is now past. Governments which fail to act on population control are likely to be liquidated as the problem grows.

I would like to explore some of the problems, discuss the opportunities to overcome them and put the potentials for improvement of food supplies into perspective. Increasing food production brings into play physical, biological, economic, industrial and human resources which interact in an organic whole. Fitting these pieces together into a properly functioning system is our real need today. There are no easy answers, only many complexities.

The Food vs. Population Problem

The thesis proposed by Malthus (1) that population increase tends to rise geometrically while food production increases arithmetically has proven to be valid. The exceptions occur only in those countries where education and high standards of living have convinced people that the cost of raising large families is too great a burden if the living standard is to be maintained. The lack of education and the need to provide old age security through having sons to care for them are to a large extent responsible for greater population increase in the developing world than in the developed. Contrast for example the United States at a zero increase level with a number of Latin American or North African countries where the percentage increase exceeds 3.5 percent.

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Even the developed world has not escaped unscathed. The development of the industrialized society has brought about mass migrations to the cities, increasing the number of poor who live in poverty, a far cry from the non-urbanized days when fresh air and hard work associated with country life were the rule. In antiquity Rome was the largest known city in the world with a population of about 800 thousand, Athens was estimated to have 140 thousand and Carthage 300 thousand. Contrast that with figures for today, Shanghai 11 million, Tokyo 9 million, New York 8 million, Peking 7.5 million, London 7.4 million, Moscow 7 million, Buenos Aires 8 million, Paris 8 million and Mexico City 10 - 11 million. "Cities can no longer be viewed as the cultural centres they once were but are more properly classified as dumps for the unemployed (2)." Employment in large cities weighs heavily on resources to maintain even the basic services of schools, police and fire protection.

It is instructive to review our increase in numbers as a sobering guide to the future. Table 1 outlines the population increase since 1750 and projects through the year 2000.

Note from the table that the percentage increase per year is gradually rising and this applied to the base number presents the problem. As already indicated, however, increases are not equal but vary from country to country and area to area. For the most part, populations of developed countries are relatively stable while most of the developing countries which can least afford them show rapid increases. This is exemplified by the following figures. In 1972 Europe, including the Soviet Union, had 957 million people and its rise was expected to be 150 million by 1990 (15 percent increase). Taken as a whole, Africa, Central and Latin America and Asia had 2,600 million in 1972 and at current increase levels, the countries on these continents are expected to have 4,300 million by 1990 (60 percent increase). This brings into focus the critical condition facing the countries of the developing world. Either food production must rise internally or they will have to import and for the latter they are economically unable to pay for the food needed. Further, transport facilities of the world would be unable to move the supplies even if available as gifts. Present exporting countries, most of which have well developed agricultural programs, would be unable to increase agricultural output in adequate amounts to supply the demand.

There is no question, therefore, that every effort must be expended to limit population increases not only from the viewpoint of food, but for provision of goods and services which will run out.

Table 1. World Population Increase Since 1750[1/]

Year	Population in Millions	Period	Annual Percent Rate of Growth
1750	791	All previous time	
1800	978	1750-1800	0.4
1850	1,262	1800-1850	0.5
1900	1,650	1850-1900	0.5
1950	2,515	1900-1950	0.8
1965 [2/]	3,281	1950-1965	1.8
1975 [2/]	4,000	1965-1975	2.2 [3/]
2000 [2/]	6,000	1975-2000	2.0 [3/]

1/ Source: John Durand Ann. Am. Acad. Pol. and Soc. Sciences 1967

2/ Source: Sterling Wortman Sci. Amer. 235: No. 3, 1976

3/ Assuming some population control can be infused. Otherwise the number could reach more nearly the 7 billion level

The Natural Resources Available

There are many misconceptions about the world we live in. The planet is quite small and its resources are finite.

Land--In the physical sense, 71 percent of the world's surface is covered by water and only 29 percent is land. Of this only 11 percent is arable. In Table 2, it can be seen that about 22 percent is in meadows and pastures, 30 percent in forests and 37 percent in tundra, desert, rock, cities and industrial sites, etc. which are unavailable for agriculture.

Revelle (3) states it in another way. The total land area, excluding the Antarctic and Greenland, is 13 billion hectares (32.1 billion acres). Of this 2.6 billion hectares (6.4 billion acres) are non-arable because frost occurs in nine months of the year; 1.9 billion hectares (4.7 billion acres) have fewer than three months when water source equals or exceeds evapotranspiration. This cuts the area due to climate alone to 8.5 billion hectares (21.0 billion acres). It has been estimated that of this only about 3.2 billion hectares (7.9 billion acres) could be conceivably cultivated. This leaves then 1.8 billion hectares (4.4 billion acres) yet to be cultivated considering present use level at 1.4 billion hectares (3.5 billion acres), about 2.3 times the present acreage. This, however, should not be construed to mean that all potential available land will have the same productive capacity as that under cultivation at present. But it does provide expansion capabilities particularly in the South American and African Continents.

Table 2. Land Resources of the Earth[1/]

	Area in 1000 Hectares	Percent of Total Land Area
Total Land Area of Earth	13,393,000	100
1. Arable Land Area (Annual and permanent crops)	1,457,000	10.87
2. Permanent Meadows and Pastures (Total Agricultural Land is therefore sum of 1 and 2 = about 33%)	2,987,000	22.30
3. Forest and Woodland	4,041,000	30.17
4. Other - (tundra, subarctic or antarctic waste, tundra, deserts, rocky waste, cities, etc.)	4,908,000	36.66

1/ 1972 FAO Production Yearbook

Water--Many areas with good soils are either nonproductive or less productive than would be the case if adequate water was available. Many areas can be irrigated if the infrastructure is installed. The current use of water flowing by rivers to the sea is about 4 percent (1000 cubic kms.) and this is being applied to about 160 million hectares (395 million acres). Unfortunately, as Revelle (3) points out, water is poorly distributed. South America, for example, has a third of the runoff on 15 percent of the land area while Southwest Asia, North Africa, Mexico, Southwest U.S., Temperate South America and The Australian Continent have 5 percent of the runoff and 25 percent of the land area.

The potential, however, for using irrigation water is particularly great in South America and to a lesser extent in Africa and parts of Asia. Revelle estimates that an investment of $700 billion U.S. dollars would be required at present day prices to irrigate and modernize agriculture in the three continents. This appears to be a great deal of money but spread over 25 years it would be a little less than $30 billion dollars per year (less than 1 percent of the gross world product). The application of such a plan would increase the irrigated area by an additional 700 million hectares (1.7 billion acres), refurbish existing systems and provide soil amelioration for acid soils and extensive use of fertilizers.

Irrigation from ground water represents a private investment by farmers who, in the case of India, showed that capital could be mobilized if incentives were sufficiently great from sources which were not evident. These operated much better than the public tubewells. The installation of new irrigation systems have great political appeal since there is great visibility, whereas improving older ones or putting in drainage systems to reclaim saline waterlogged soils are not favored. An outstanding example is Pakistan which cries out for drainage but it is not being done. Continuous maintenance would be better but this also is not well performed.

Large schemes are more easily installed than the smaller schemes for a whole variety of reasons which have been enunciated by Levine (4). They are needed if large variable amounts of water are to be controlled, limited manpower skills can be utilized, operation and maintenance are easier, finance is easier to obtain and administer and they generate work during construction and after in project operation. However, many of these large projects tend to neglect the installation of adequate drainage systems, adequate control of erosion in the watershed to avoid silting of the reservoir and a proper delivery system in secondary and tertiary channels. Unless the multi-objective approach is followed, irrigation systems will be inefficient and sometimes uneconomic in the longer term.

More efficient use of water is needed. Israel with drip irrigation has shown one approach and Taiwan uses especially trained irrigators who are hired by a group of farmers to deliver water in especially constructed channels. Irrigation water should be paid for on a volume basis rather than by turns. Unfortunately, this practice is not widely followed and the result is poor efficiency of water use and actual damage to the crop and land through waterlogging.

Better control of rainfall that falls on the land may have even greater relevance to increasing yield since very large areas are involved in rainfed agriculture. Better tillage practices and weed control in Turkey, for example, have shown 70 percent yield increases, largely due to water conservation. Small dams, timing of cultural practices and incorporation of organic matter will provide greater moisture holding and maintaining capacity in the soils.

Water management then is a second method of effectively increasing yield and production since the farmer will more readily invest in the auxiliary inputs if risk is removed through access to adequate water.

Fertilizers--Chemical fertilizers will be required in greatly increased amounts if the world's people are to be fed, irrespective of any developments otherwise that might be forthcoming. Food faddists would have us believe that the food crisis will be solved if we use dung and waste products of plants more widely. I would not disagree with the need to recycle if for nothing other than to control pollution. In 1975, however, in addition to the organic fertilizers used, about 47 million tons of chemical Nitrogen were used. A calculation of the size of the dung pile required to equal this amount in Nitrogen tonnage gives a figure of 3.2 billion tons or enough to build a road 117 meters wide and 2 meters deep around the earth at the equator! Further, it would require the collection of droppings from twice as many animals as we now have. It is apparent to agriculturalists that the cost of transport at today's wages would be prohibitive.

Nitrogen is currently produced most cheaply from petroleum products, naphtha and natural gas as well as from coal. A more expensive method is by compression of atmospheric Nitrogen and hydrolysis of water to provide H and O_2 for combining in Calcium ammonium nitrate. This method is used in only one or two production plants.

Dr. Raymond Ewell (5) estimates that the world should invest about seven billion dollars annually for each of the next five years if the needs for fertilizer are to be met. China alone is currently building twelve one thousand ton per day plants. In Table 3 are shown the fertilizer use data for the world with projections to 1980. In the second part of the table are corresponding figures for the United States for the period 1969-1974. These figures do not show the relatively higher percentage increase in fertilizer use by the developing countries. In these developing countries fertilizer usage has increased at a relatively faster rate than in the developed countries up to 1972 and they are again coming back strongly into the market.

Table 3. Nitrogen, Phosphorus and Potash Consumption

World Consumption in 1,000 Metric Tons

Year	Nitrogen	Phosphorus	Potash
1973	38,449	24,096	19,581
1974	41,349	25,412	20,661
1975	44,349	26,770	21,773
1976	47,442	28,163	22,913
1977	50,633	29,593	24,084
1978	53,917	31,053	25,280
1979	57,293	32,551	26,506
1980	60,762	34,080	27,760

Source: World Fertilizers Market Review Outlook, National Fertilizer Development Centre, T. V. A., Muscle Shoals, Alabama 1974

United States Consumption in 1,000 Metric Tons

Year	Nitrogen	Phosphorus	Potash
1969	6,937	4,653	3,873
1970	7,437	4,565	4,018
1971	8,114	4,796	4,216
1972	7,995	4,865	4,310
1973	8,276	5,078	4,634
1974	9,099	5,062	5,069

Source: 1975 World Fertilizer Situation USDA Economic Research Service December 1974

Critics state that fossil fuels should not be used for Nitrogen production. Such views should be considered in the light of a New York Times editorial of April 29, 1974 stating that sufficient gas was being flared in Saudi Arabia alone in the course of a year, to provide the entire energy and feedstock needs of 167 one thousand ton per day urea plants with a rated capacity of 45 million tons. This is almost equal to the entire usage of Nitrogen in the world in 1975. Is it better to burn this gas into the air or turn it into Nitrogen?

Phosphorus, the second major fertilizing element, is a nonrenewable raw material, unlike Nitrogen which can be obtained directly from the atmosphere if the need is great. As a result, the continuing supply of this element is of considerable concern. Revelle (3) indicates that estimates have been made of an availability of 18 billion tons of high grade phosphatic rock which should provide for about 450-600 years use at expected levels of the year 2000. Moreover, reserves of lower grade rock about eight times this amount are known, and further reserves of presently uneconomic rock are known. Recently, mining of Phosphorus from the sea has been proposed but such recovery costs may be so great that it would be cheaper to recycle all Phosphorus taken from the soil. In most of the countries where farming has been conducted for centuries or even thousands of years, the soils are impoverished. In such cases where irrigation is practiced Phosphorus is needed at about one half the rate of Nitrogen applied. Under dryland farming it is usually nearer the 1 Nitrogen: 1 Phosphorus ratio.

The United States has large reserves of phosphate rock primarily in Florida where according to the International Minerals and Chemicals Company, 40 million tons per year are being mined. The U.S. uses about 300 pounds per capita as compared with most countries where no more than 50 pounds per capita are used.

Potash is required in much lesser amounts than the two other major elements. For certain high potash utilizing crops such as potatoes and tobacco, relatively larger amounts are required. In many soils where the parent material is micaceous, the need is not widespread. Very large reserves of this chemical have been identified in Canada and other countries which ensures an adequate supply of this nutrient for some centuries.

Of increasing importance is the role of micronutrients in the soil. As the various tropical and subtropical countries come under ever increasing pressure to provide food for their populations, multiple cropping of the same land in succeeding seasons is rapidly increasing as a practice. Additionally, with crops which respond to fertilizer becoming widely grown, high yields are removed from the land in each crop cycle. The result has been that in some countries, such elements as zinc, iron, manganese, copper, sulfur and so forth have become the limiting factor on yield despite heavy applications of the major elements. The need is evident for careful monitoring of the nutrient level to ensure continued productivity of the soils.

The price of fertilizers rose dramatically in 1972 as a result of the rise in price of petroleum and the concomitant jump in the price of phosphate rock through the unilateral action of the OPEC nations and Morocco, respectively. This was further aggravated by widespread speculation. The fertilizers became so expensive that farmers refused to buy adequate amounts and some poor countries who desperately needed food had to provide fertilizers at a highly subsidized rate. Cost of foreign exchange alone was ruinous.

The lack of sales coupled with the higher prices which encouraged manufacturing led to the accumulation of very substantial inventories. Prices fell from $350 per ton for urea in early 1975 to about $100 per ton at the end of the year. Similarly, for Phosphorus, the price of diammonium phosphate declined from about $400 to $150 and continued to fall to about $100 per ton in March of this year. All fertilizer elements have been similarly affected.

It would appear that the fertilizer manufacturers have real difficulty in developing and maintaining a stable market. I would expect, however, that costs will begin to turn upward with increasing rapidity as farmers and countries again take advantage of lower prices. In my opinion it should stand as a warning to the industry that such short-term tactics of unreasonable raises in price, harm the market in the longer term.

Food Sources--It would seem desirable at this point to look briefly at the sources of our food crops. In Table 4 one can observe the source of some of our major foods. Even using such gross measurements where a pound of potatoes or milk equals a pound of cereal grain, the cereals still make up more than 40 percent of the total food production. Loomis (6) states that 50 percent of the protein and energy of humans comes from the cereals in direct consumption. If the grain fed to animals and that used in brewing and other industrial purposes is also included, the cereals actually contribute 75 percent of both energy and protein. He states that man depends primarily on 11 species of plants for human and to a lesser extent animal nutrition. Although these are not mentioned, he probably refers to wheat, rice, corn, barley, oats, millets, sorghum, sugar, potatoes, sweet potatoes and soybeans. It may be seen that 8 of these 11 species are from the grass family Gramineae.

The area, production and yield of 11 principal food crops were compared in the 1965 and 1974 Food and Agriculture Organization Yearbooks. Data presented for the various continents and the USSR indicated that on a world basis, the wheat area has increased only 4.5 percent but was up nearly 32 percent in production; rice increased 10.6 percent in area and 26 percent in production; maize 3.5 percent in area and 29 percent in production, barley has shown exceptional growth of 30 percent in area and 55 percent in production; oats, on the other hand showed little growth in acreage

Table 4. World Food Production 1974

			Millions of Metric Tons	Percent Total Food Production
I	From the Land [1]			
	A	All Cereals	1,333.9	40.7
		Wheat	360.2	
		Rice	323.2	
		Maize	293.0	
		Barley	170.9	
		Other Cereals	186.6	
	B	All Root Crops Potatoes, Cassava, Yams, etc.	559.9	17.1
		Potato 293.7		
	C	All Pulses Grain Legumes - Beans, Peas, Chickpeas, etc.	44.1	1.3
	D	All Vegetables and Melons	123.8	3.8
	E	All Fruits	204.7	6.2
	F	Nuts	3.0	0.09
	G	Vegetable Oils	137.1	4.2
	H	Sugar	92.3	2.8
	I	Coffee	4.9	0.1
	J	Cocoa Beans	1.5	0.05
	K	Tea	1.6	0.05
	L	Meat	208.4	6.4
	M	Milk	424.3	13.0
	N	Cheese	10.7	0.32
	O	Butter and Condensed and Evaporated Milk, etc.	16.1	0.49
	P	Eggs	23.2	0.71
	Q	Honey	.8	0.02
	Total All Foods From Land		3,190.2	97.3
II	Total Fishery Catch From Ocean and Inland Waters [2]		86.1	2.6
	A	For Human Consumption 47.5		
	B	For Other Uses (Oils & Meals, etc.) 18.6		
III	Grand Total of Food From Land and Water		3,276.3	100.0

1/ FAO 1974 Production Yearbook
2/ FAO 1974 Yearbook Fishing Statistics

although production rose by 13 percent; millets and sorghum were grown on 7 percent more acreage and production increased by 21 percent; sugar showed a decline in production, but this crop is subject to wide fluctuations in response to price; potatoes held a relatively stable level with acreages changing for different continents; sweet potatoes and yams showed a marked increase of 30 percent in acreage and 24 percent in production; soybeans have gone up by 60 percent in acreage and 78 percent in production.

It is evident that crops on which research has been concentrated have been the greatest recipients of yield increases. Wheat, barley and maize have increased in yield per hectare by approximately 25 percent. Rice, which has had some problems with water control and certain diseases, only increased in world wide yields by 14 percent. Oats, potatoes, millets and sorghum and soybean yields increased about the same amount. Sweet potatoes and yams on which virtually no research has been done showed a decline in yield.

It should not be inferred that these gains are all genetic although that is needed as a precursor to fertilizer use and better technological practices. It should be pointed out that these gains are over the base figures of 1964. Wheat, barley, oats, millets and sorghum are produced for the largest part under conditions of relatively limited moisture outside the subcontinent of Asia and even there much of the crop is rainfed. In rice, maize, sugar and soybeans, the crop is generally grown under irrigation or conditions of ample rainfall. It is significant that both yields and production are rising in spite of a relatively limited acreage devoted to the high yielding varieties of a number of these major crops.

It may be noted in Table 4 that only 2.6 percent of man's food comes from the sea and inland water fisheries. Yet, one hears repeatedly that when the food reserves of the land run out, we will turn to the sea. This is simply wishful thinking since according to Cousteau (communication to CIMMYT) and others, many of the species of seafood are already over exploited and fisheries actually need protection if they are to continue to produce even at the present level.

It seems evident, therefore, that man's food will continue to be produced on the land and this will have to be done with the aid of better varieties, better technology, better organization and above all the necessary will.

The Adoption of New High Yielding Varieties

In Table 5 are some of the estimated acreages showing the spread of the new varieties in the developing world. In wheat it is evident that India and Pakistan lead the field with Argentina a strong third. However, additionally, six other countries have more than one million acres, ten have more than

Table 5. Acreage Devoted to High Yielding Varieties in the Developing Countries[1] (a partial list)

Country	Year	Wheat	Year	Rice
		Crop Areas 1,000 Acres		
Asia				
Bangladesh	1968-69	20.8	1966-67	0.5
	1975-76	235.0	1974-75	3,567.0
Burma			1966-67	0.02
			1975-76	915.0
India	1965-66	7.4	1964-65	.2
	1975-76	31,134.0	1975-76	30,887.5
Indonesia			1968-69	489.9
			1974-75	8,500.2
Korea			1971-72	6.7
			1975-76	1,112.0
Laos			1966-67	.9
			1972-73	123.6
Malaysia			1965-66	104.5
			1973-74	536.3
Nepal	1965-66	3.5	1968-69	105.1
	1974-75	610.0	1074-75	550.1
Pakistan	1965-66	12.0	1966-67	.2
	1974-75	9,100.0	1974-75	1,559.0
Philippines			1966-67	204.1
			1974-75	5,374.4
Sri Lanka			1968-69	17.2
			1974-75	870.0
Thailand			1969-70	7.4
			1975-76	1,482.6
South Vietnam			1967-68	1.2
			1974-75	2,223.9
China	no estimate		no estimate	
Middle East and North Africa				
Afghanistan	1966-67	4.5		
	1974-75	1,289.9		
Algeria	1969-70	12.6		
	1974-75	1,600.0		
Egypt	1970-71	0.4	1965-66	?
	1975-76	150.0	1974-75	16.8
Iran	1968-69	25.0		
	1973-74	644.9		
Iraq	1967-68	15.8	1972-73	12.4
	1974-75	1,853.3	1974-75	37.1
Lebanon	1967-68	0.1		
	1972-73	49.4		
Morocco	1967-68	0.5		
	1974-75	741.3		

Table 5. Acreage Devoted to High Yielding Varieties in the Developing Countries[1/] (a partial list)
(con't.)

Country	Crop Areas 1,000 Acres Year	Wheat	Year	Rice
Middle East and North Africa - (con't.)				
Saudi Arabia	1972-73	0.4		
	1974-75	24.7		
Sudan	1972-73	6.0		
	1975-76	311.3		
Syria	1970-71	94.0		
	1974-75	664.7		
Tunisia	1967-68	2.0		
	1974-75	135.7		
Turkey	1966-67	1.5		
	1974-75	1,700.0		
Ethiopia	1968	1.0		
	1972	45.0		
West Africa				
Cameroon			1975	1.0
Ivory Coast			1972-74	7.4
Liberia			1973-74	30.0
Nigeria	1966-67		1973	1.5
	1974-75	11.0		
Senegal			1976	7.4
Zaire			1975	0.04
Latin America				
Argentina	1973	50.0		
	1975	6,300.0		
Brazil	1975	750.0	1974-75	86.5
	1976	1,000.0		
Chile	1958			
	1976-77	476.0		
Colombia			1968	0.2
			1974	669.1
Costa Rica			1970	39.5
			1975	201.6
Cuba			1974	198.0
Dominican Republic			1972-73	25.0
Ecuador			1971-72	17.5
			1973-74	61.9
Guatemala	1975	74.0		
Honduras			1972-73	4.2
Mexico	1976	2,000.0	1971-72	247.0
			1974-75	267.9
Nicaragua			1974-75	51.2
Peru			1971-72	65.4
			1974-75	154.0

Table 5. Acreage Devoted to High Yielding Varieties in the Developing Countries 1/ (a partial list)

(con't.)

Country	Year	Crop Areas 1,000 Acres Wheat	Year	Rice
Latin America - (con't.)				
Venezuala			1973	75.0
			1975-76	296.5
World		60,150.2		59,818.8

1/ Source

Development and spread of high yielding varieties of wheat and rice in the less developed nations. Dana G. Dalrymple. Foreign Agricultural Economic Report No. 95. Economic Research Service. United State Department of Agriculture and USAID. Considerable acreages are also being grown in both crops in developed countries.

one hundred thousand acres and five have less than one hundred thousand acres. The new variety total for wheat is about 60 million acres as compared with the total area of the world planted to wheat of 555 million acres. On the basis of these figures, about 10.8 percent of the wheat area is in high yielding varieties. This does not tell the complete story since developed countries have not been included in the list. It is known for example that 85 percent of California and nearly all of Arizona and New Mexico wheat acreage is in Mexican varieties. The Soviet Union and China are known to have made large imports of these from India and Mexico respectively, over the past several years. The extent to which they have spread in these countries is not known but could amount to some hundreds of thousand acres.

In rice, the other crop in which high yielding dwarf varieties have made an impact, the field again is led by India, followed by Indonesia, the Philippines and Bangladesh. Additionally, there are four countries with more than one million acres, 11 with over 100 thousand and 13 with less than 100 thousand. In total there are again about 60 million acres which may be compared with the 463 million sown to this crop. On the basis of these figures nearly 13.0 percent of the total rice area is sown to high yielding varieties.

In relation to food production, the significant factor is that high yielding varieties of these two crops have achieved the greatest world distribution of any of the major cereals. Yet, the percentage area covered is still relatively small but the impact of these varieties on production, reflected in the yield gains, has substantially increased grain supplies. There has been a rub off on almost all other crops in the level of technology being applied in countries to which they have spread. Figures are not available for the areas in which new varieties of the other crops are being grown but it is generally agreed that none of these has yet been accepted over the same area as that of the two major cereals, wheat and rice.

The 1976 Crop Year

In general, high yields have been experienced by many countries during the current season with the exception of certain countries in Western and to a lesser extent Eastern Europe, where drought was the worst in many centuries. See Table 6. The USSR harvested a near record crop as did the United States, Canada and Argentina, the latter three traditional exporting countries. South Asia harvested record or near record crops in India, Pakistan, Nepal and Bangladesh. Flooding in Pakistan damaged some of the rice plantings and Sri Lanka was down in its rice production. Generally good crops were harvested throughout Southeast Asia.

In North Africa the wheat crop was well above recent years with a record production in Tunisia and good crops in Morocco and Algeria. In Egypt the economic incentives for growing high yielding wheat varieties have reduced acreage considerably from more than 500 thousand acres to about 150 thousand. Crops are still above average. In the Middle East, Iraq and Iran harvested bumper crops. Crops were reasonable in Jordan but Lebanon, because of the war, had a very poor harvest. Israel had drought and will need imports. Turkey probably harvested close to 15 million tons of wheat but has been unable to sell it because of a depressed world market with prices much below the internal support price. They need to build long-term storage as is also the case in Tunisia. Both countries have high potential for extra production.

In Ethiopia, the disturbed political situation has resulted in undesirable effects on research and production. In Kenya crops were not up to previous levels.

In Latin America, Argentina is expected to harvest a record wheat crop of 10-11 million tons. The recent moves on the part of government to rationalize the price of imported fertilizer and allow the farmers access to the world price for crops is primarily responsible for the upswing in production. It may be predicted that if these policies are continued, Argentina will again become a major exporter capable of supplying much of Latin America.

Brazil is rapidly opening new lands which are available for production. It is estimated that more than two million hectares are being developed each year. Soybean production, as is well known, has advanced at an incredible rate reaching 10-11 million tons last year up from almost none four years ago. In the current season the wheat crop was subjected to continuous rain in the Parana region and associated heavy attacks of disease will reduce the crop materially.

Chile has suffered drought conditions. Last year the wheat crop was badly affected by disease; barley yellow dwarf caused by a high aphid population. Resistant materials are being increased but it will be some time before these will have an effect.

Table 6. Partial Estimates of Grain Crop Production in Various Countries

USSR	129 million hectares of grain producing expected 215 million tons their target.
Western Europe	124 million tons of production - 9 percent below the previous 5 year average. Wheat up to 51 million tons from expanded acreage. Coarse grains down by 9 million to a total of 72.6 million. Potato harvest poor as were fruits and vegetables.
Australia	1976 wheat crop down from drought estimated 7.75 million tons down from 11.7 in 1975.
Canada	Wheat crop 20 million tons largest since 1966. Coarse grain 20 million tons up from 1975.
Eastern Europe	85 million tons of grain. Small grains down. Corn making 26 million tons is a little down from last year. Oilseeds up in acreage from 1.8 to 2.0 million hectares. Sugar beets same as last year, potatoes declined. All crops down some from drought.
China	Early harvested crop below 1975 level but still near record level. Wheat about 39 million tons (winters good, springs poorer). Coarse grains like 1975. Early rice crop may be slightly smaller than record 1975. Soybeans may be down.
India	Output forecast at 110-113 million tons. Wheat near record at 27-28 million tons. Rice may be down by 10 percent from 47.4 million in 1975-76. Coarse grains about 30 million tons.
Indonesia	About 15.3 million tons of rice.
Philippines	Self sufficiency in both rice and maize.
Thailand	9.6 million tons of rice. 2.7 million tons of corn down by .5 million.
Bangladesh	12.7 million tons of rice down slightly. Wheat increased by about 100,000 acres.
Pakistan	Record wheat harvest (officially 8.4 but probably 9.0-9.5 million tons. Rice damaged by floods down.
Sri Lanka	118,000 tons of second rice crop down from 400,000 tons. Need imports.
Argentina	5.8 million tons corn. Down 4.8 million tons sorghum. Down 10.0 million tons wheat up by 2 million tons.
Brazil	Corn and rice production up sharply. Will export 2 million tons. Soybeans 11 1/2 million tons up from last year by 1 million tons expected. Wheat - rains and septoria reduce the crop markedly.

Table 6. (con't.) Partial Estimates of Grain Crop Production in Various Countries

Brazil (con't.)	Parana will be about 600,000 tons of poor wheat. Total will be perhaps 2.6 million.
Mexico	Wheat up some from previous year because of acreage increase 3 million tons, 268 tons of safflower. No frost and 10 million tons of maize. 1.4 million tons of sorghum. 88,000 tons of chickpeas. 460,000 tons of tomatoes.
Colombia, Peru and Ecuador	Good season but perennially importers.
Chile	Wheat crop down because of disease and drought. Imports needed.
Venezuela and Guyana	Rice crops damaged by flooding.
Morocco	No estimate but wheat crop excellent.
Algeria	About 2.8 million tons estimated.
Tunisia	About 1.5 million tons estimated. (for the 3 countries imports will be down) Tunisia will export.
Egypt	Production will be up slightly but imports of 1.7 billion are expected.
Kenya	Wheat and corn are down but buffer stocks are high so imports not required.
Angola	Because of war the country will import wheat.
Madagascar	Rice production still with problems. Imports needed.
Mozambique	Will import 50,000 tons of rice and 100,000 tons of wheat.
Zaire	Wheat imports 120,000 tons. Corn increased production to 420,000 tons. PL48 imports will continue on rice and cotton.
Iran	Record 5.5 million tons wheat up 10 percent but imports of 900,000 expected. Rice unchanged at 800,000 tons imports 250,000 tons.
Iraq	Wheat 1.6 millions double the 1975 harvest. Import rice and wheat.
Israel	Wheat down from drought imports 500,000 tons.
Jordan	Wheat 68,000 tons up 36 percent from 1975. Imports about 255,000 tons.
Saudi Arabia	Rice reports 300,000 tons. Wheat reports 800-850,000 tons.
Turkey	USDA reports 12.5 million (personal communication 15.0 million) can export considerable quantities but international price below support price. Barley yields high. Sugarbeets high.

Source - World Agricultural Situation
Economic Research Service, United States Department of Agriculture
October 1976 plus Personal Communications

Mexico had favorable weather with no widespread frost on the summer corn crop. Estimates for the year are three million tons of wheat and ten million tons of corn.

Other countries of Latin America had equal or better crops than in 1975 except for Venezuela and Guyana where the rice crop has been damaged by flooding.

In summary the world food situation has been somewhat eased. According to a recent report of October 12 (7) the USDA forecasts a record cereal grain crop of 1.3 billion metric tons. The world stock of grain was considered to be 120 million tons and it was felt that perhaps 25 million tons would be added to existing stockpiles of grain for the coming year.

The Export Outlook

Exports and imports must be looked at in the light that today's surplus can disappear very rapidly with one poor crop year as exemplified by 1972. It takes between 25 and 30 million tons additional each year just to maintain per capita consumption since 80 million additional people sit down to the table every year. Thus, even though this year has been generally good and we have a small addition to make to the reserve, this is the first time that this has happened in the last four years.

As has been indicated wheat production was up and, as expected, this has led to a reduction in price over the previous highs. The gain was about 35 million tons, 10 percent above the previous crops. Rice suffered a seven to eight million ton loss in production but its prices also will come down as substitution of wheat for rice is made by the importers. Coarse grains being up about five percent or 34 million tons will probably remain fairly firm particularly in view of the drought throughout Europe which will increase demand.

In the exporting countries, the United States, Canada, Argentina and perhaps the USSR, all will have ample supplies to provide food for the present year. Overall increase in grains in these countries has been set at 55 million tons. The developing countries on the other hand, have increased their total food supply by an estimated 15 million tons.

Trade in coarse grains may fall off as cheaper wheat will encourage more sales of wheat as opposed to coarse grains in importations for human food.

Some of those countries that are normally substantial importers and whose grain supply is often in jeopardy may elect to take advantage of the lower prices of wheat this year to build up buffer stocks within the country. India over the past several months has been gradually building up her stockpile with the aim of having 16 million tons in store as a buffer. Others may follow suit.

Bangladesh has had two good crops in succession and is unable to take care of food already in the country because of a lack of storage. Pakistan will import some wheat although as a country they should be exporters, not importers. They will continue to export some quantities of rice. Southeast Asia will see imports of rice to Indonesia and continued exports of maize and rice from Thailand. Sri Lanka will require imports of rice.

In Latin America, the big news is Argentina which will again become a major wheat exporter with production rising to 10 or 11 million tons this year. Brazil of course will continue to export soybeans but will have to import larger amounts of wheat because of inclement weather in Parana. Chile's poor crop last year is likely to force an increase in its imports. The Andean countries will continue to import at about the same level.

In the Middle East and North Africa, high levels of production will cut imports appreciably for almost all of the countries. As mentioned, Turkey and Tunisia can offer considerable quantities for export. Tunisia will confine most exports to durum wheat for the European Common Market and some to Libya. Similarly some of the durum wheat of Turkey and the Middle East is likely to find its way into Europe as well. Morocco and Algeria will have a lower import requirement this year. East Africa, Sudan, Egypt, Mozambique, Zambia, Tanzania, Uganda and Malagasy will be importers.

The USDA states that soybean exports from the U.S. are likely to decline from the 15.4 million metric tons registered last year. Demand is growing for additional soybeans for feed but Brazil as the second largest producer will be expected to take a considerable part of the market. The lower prices for grain are also expected to increase grain feeding at the expense of soybeans. Wheat and grain shipments are expected to drop off by 10 percent. The forecast for U.S. agricultural exports as a whole are estimated at 22 billion dollars and imports at 10 billion, leaving a net of 10 to 12 billion dollars trade balance in the U.S. favor.

World Price Developments

With the news that excellent crops were being produced in the traditional exporting countries, coupled with the good crops in some of the traditional importing countries, the price of all grains declined as already mentioned. This of course was to be expected in a free market since wheat, rice and some of the coarse grains can be interchanged and a decline in one brings a decline in the other interdependent cereals.

The forecast that wheat would go below $3.00 per bushel was realized. By mid September cash price on the Chicago market for wheat was $2.88, corn $2.81 and soybeans were selling at $6.46. Prices continued to decline and by October 26 had fallen to $2.73 for wheat. After a further decline in corn the price began to pick up and stood at $2.46 by October 26. Soybeans dropped slightly but by October 26 had moved back to $6.35.

One should always be careful about looking into a crystal ball on prices. If we could do this, all of us who are potential speculators would be rich. However, it is difficult to see how, barring a large scale crop disaster, the price of wheat can be expected to improve greatly in the coming year. Supplies are adequate and good crops are forecast again for next year. As was pointed out, wheat has traditionally acted as the buffer crop, taking the place of rice when it is in short supply. It also will take the place of maize for feed if maize or other feed grains become too high in price. The one thing that could pick prices up in wheat would be the establishment of an international buffer stock which has been under discussion.

Argentina has a very large potential for producing wheat and maize and if the present policies are continued, Argentina will begin to absorb some of the international market, particularly in South America and Europe. In corn the price is likely to sag for a short while but will not exceed the wheat price. Soybeans, we are told, are likely to be increasing in price due to a reduction expected in acreage which will move to cotton since cotton has again become profitable on the world market. Less acreage would mean less beans and unless Brazil takes over a major portion of the export market the price should rise next year. Brazil is a country, however, which should not be left out of the picture. It is booming and moving rapidly ahead.

The exporting countries will probably develop some buffer stock storage system but it is likely to be of relatively short duration.

Grain Supply and Policy Developments

There is a need for a new set of policies regarding food supply for the world. In the past the exporting countries have been expected to act as the food broker of the world and provide food where and when it is needed in areas of scarcity. This led to the development of often burdensome surpluses for which the taxpayers had to provide money for storage. In turn this led to the introduction of the PL 480 and similar concessional grain sales from the exporting nations.

This had three effects. Firstly, it provided food for needy countries which can only be considered a plus from their point of view. Secondly, it was an escape valve through which surpluses could be funneled to keep the efficient farmers of the exporting nations in business and at the same time relieve the burden of storage--a plus from the viewpoint of the farmer and taxpayer in the developing countries. Most of them wished to industrialize and copy the Western World's pattern of development but they wanted to do it in a short time from an economic base which was strictly agricultural. They used PL 480 grain to keep consumer prices low in the cities. To quote Hopper (10) "It is easier on their national budgets to farm the fields of the U.S. and Canada" and to use the funds generated through PL 480 sales to develop the industrial base. In the process they neglected research and production at home, allowing prices to stagnate, giving no incentive to their farmers to produce more grain. The result was a lack of agricultural development in most of the countries. Those of us working in international agriculture have been aware of its ill effects for many years.

Among the first to see the error of this approach were India and Pakistan. In the mid 1960's they decided that the import levels were making them completely dependent on other countries for food so they embarked on programs to encourage their own farmer production. Their increasing level of imports just could not go on. It was no accident, therefore, that these countries which belatedly looked to their agriculture were the first to experience the so-called "Green Revolution". I will say very little more about PL 480 type sales but in some countries they have been used by the supplying governments as foreign policy instruments. Under such conditions there is virtually no initiative on the part of the recipient governments to change their agriculture. It is fair to say that unless the leaders of governments do come to grip with the problem and stop procrastinating, they are almost bound to be laid to rest by the political unrest of the disenchanted farmers.

Since 1972 the U.S. government has owned virtually no stocks of food or feed grains and has actually had to move toward greater control of exports in order to create more stability in the U.S. consumer market. In a recent unpublished paper by Hathaway (11) he very rightly points out the value of having grain stocks as a basis for economic stability. The 1972 reduction of food reserves had a far reaching effect on the market, not only in food prices but the fertilizer markets. Moreover, there was a domino effect on prices of manufactured goods as labor leaders fought for higher wages for the workers to return take-home pay to the pre-1972 level. This, associated with the OPEC price increases, set off the wage-price spiral and the worst inflationary period of recent time. The returns to the farmer in this period, it should not be forgotten, were relatively minor viewed in terms of the wheat in a loaf of bread but the associated rise in the processing chain was extremely high and food prices rose sharply.

Adequate stocks of food can be used to buffer the market and prevent these wide fluctuations. The undesirable effects of the wide oscillations in price is felt by the farmer as well as the consumer since it leads to a boom and bust type of farm economy. He does not know whether he should invest in inputs or not. To the people of the developing world without OPEC or similar type of foreign exchange income, such fluctuations are a disaster. Thus, adequate food reserves can be looked at as an insurance against inflation but a premium must be paid, namely the storage of such adequate stocks. The question is who should pay?

Because of the crisis of 1972, a number of actions have been taken. These involve change in U.S. national policies and also certain international policy initiatives. In 1975 the United States entered into an agreement with the USSR in which it was agreed that over the following five years the U.S. would provide annually to the Soviet Union 6 to 8 million metric tons through commercial channels unless the U.S. grain supply were to fall below 225 million tons. This was done to prevent a recurrence of the unsettling effects of the 1972 large grain purchase from that country.

At the same time agreements were reached with Israel and Japan that they would be supplied fully with their requirements but that on their part they should estimate three years ahead as closely as possible what their import requirements were likely to be.

A five year understanding with Poland and a one year understanding with Roumania were signed. Under these five agreements, the U.S. would sell 20 to 23 million tons of grain and 3.5 million tons of soybeans. The signing of these agreements will undoubtedly put pressure on countries outside the agreements to make some other type of bilateral arrangements to ensure their food supply.

In the international field, the World Food Conference of November 1974 called for a world food security system. The U.S. put forward a plan to store 30 million tons of wheat and rice but there has been little progress on this proposal.

A second initiative arising from the conference was the formation of an International Fund for Agricultural Development (IFAD). It was decided that when one billion dollars were subscribed, the fund would come into existence. There has been considerable discussion on who is to subscribe how much but it appears that the fund will become a reality.

The Food Conference further estimated that the developing countries would need investments of five billion U.S. dollars in foreign exchange each year for the next 20 to 25 years if the world was to be sure of a secure food supply. They recommended the formation of a World Food Council and a Consultative Group on Food Production and Investment in addition to the IFAD mentioned above. These groups, it was felt, were necessary to mobilize these levels of investment. Again progress has been minimal. The World Bank has been devoting increasing amounts of its resources to agricultural development and this could increase food supplies materially.

A more regional approach has been organized by the Arab nations known as the Arab Authority for Agricultural Investment and Development with 525 million dollars initial capital and 2.8 billion for rural development and food production in the Middle East with particular emphasis on developing the agricultural potential of southern Sudan. That country, however, will require massive developments of infrastructure before it will become a granary of the Arab world.

All of these initiatives look good on paper but the proof of their worth will be measured on the effectiveness with which they are put into operation. There seems little question of the need for a world food bank, both to alleviate distress and provide buffer drawing stocks under international funding. Equally, there is no question of the need for increasing the potential food

supply in each country. But all plans need people with dedication and freedom to act if they are to be effective. Are there enough such people willing to devote their efforts to this pursuit and more importantly, do the governments care enough or will they allow narrow nationalism to stand in the way of cooperation? Unfortunately, it is more likely that the present short-term easing of the food crisis will simply fill them with a complacency that will only be shattered by the next crisis, soon expected.

The Citizen View of Agriculture in the Developed World

Biologists have failed dismally in presenting the case of agricultural production to the urban citizen. In a similar fashion the farmer has also failed to communicate. The urban dweller, born and raised in the city, is faced with food on the supermarket shelf. Few, if any, have ever had the opportunity to see where the food is produced. Surely, coming home on weekends, he picks up some vegetables from that quaint roadside stand but by and large the food grows in the supermarket. He sees nothing of the toil, long hours, fight against insects, rodents, hail, frost and bad weather. In dim imagination he may think of this but the supermarket cornucopia soon drives that out of mind.

Forecast of Food Needs

A definitive report issued by the new International Food Policy Research Institute (12) deals with the cereal needs in coming years for more than half the world's people who live in countries classified as developing market economies (DME) as opposed to the centrally planned Asian governments such as the People's Republic of China. By 1985 the report states these countries will have 2.5 billion people of whom 2.2 will live in food deficit countries. The situation is precarious and may soon be alarming.

Unless present performance improves, the report forecasts a shortage of 95 to 108 million tons by 1985-1986 compared with the 45 million tons shortfall in 1972. Asia would have more than 50 percent of the deficit, North Africa and the Middle East 20 percent and Sub Sahara Africa and Latin America 15 percent each. This is considered conservative because it is based on cereal increases from 1960-1974 whereas the trend is lower in the latter half of that time. If the latter trend continued the shortfall could be 200 million tons.

Large amounts of capital will be needed by countries that are very poor and responsible for half the deficit if their production is to be raised. It is unlikely to take effect early enough and concessional food aid will be needed. Unless help is effective, consumption will decline and under greater malnutrition they will be less likely able to help themselves. They list various countries which will have deficits such as India, Bangladesh, Indonesia, Nigeria and countries of the Sub Sahara. Other countries with high income make up 8 percent of the DME population. These OPEC nations will command food imports because of ability to pay. About 20 percent of the DME population

live in middle income food deficit countries. Some of these can import commercially, others will need concessional food aid. Only about 13 percent of the DME population live in countries which export cereals. They will likely sell only on a commercial basis rather than on a concessional sales basis.

The forecast is that the People's Republic of China has the potential of becoming a cereal exporter but it is almost certain that available supplies would be used to improve diets in China or help other Asian centrally planned economies.

This paper is not alarmist but is a considered view of the needs within the next decade. Several bright spots previously referred to may cut the deficit situation by substantial amounts but there is little hope that all of the deficits can be cut and the job of even supplying concessional food because of shipping problems may be extremely difficult.

Reflections on the Future of Crop Production for the Developing Nations

Each year to maintain the present inadequate level of food consumption, 25 to 30 million tons additional grain is required to feed the additional people. We have looked at land availability and there is indeed considerable land yet to be brought into production in South America and Africa in particular. Some of the countries of South America will shortly begin to add to the commercial export market, those in Africa may in the future after much development work. In Asia where populations are still advancing alarmingly, not so much on a percentage basis but because of the large base population figures of 900 million in China, 620 million in India, 65 million in Pakistan, 80 million in Bangladesh and so on, food can only be bought by certain of the countries that have foreign exchange. For the most part in these countries increased food production will have to come from the same land area through increases in yield per hectare per year. Multiple cropping, relay cropping and better application of improved technology offer some of the answers.

Wortman (13) lists three ways in which the food problem of the developing countries cannot be answered. Larger harvests in surplus countries do not provide an answer since, as we have seen, giving it to the deficient countries allows them to neglect their own agriculture. Thus, this is often counter-productive since it simply delays the evil day when those countries must pay the piper. Introduction of western type large scale farming is not the answer except in areas where there are large undeveloped lands still available. In most countries it will not work because food has to be sold and people have to have money to buy and therefore they must have work. Given sufficient land, small scale operation with greater family care can increase output per unit area even though output per man year is abysmally low. A third non-applicable approach is the "easy way out" production of synthetic foods. Manufacture of such food does not give large scale employment, therefore the people could not buy since they do not earn.

We have seen that the development of much more of the world's irrigation could add to the earth's productivity and that the wider and more intelligent use of fertilizers can also provide much more food. Reclamation of non-productive but formerly productive lands which have been salinized offers still further scope.

In the biological sphere new varieties which have superior yields are being developed at an unprecedented rate. Yet we biologists are constantly admonished by the non-biologist that the varieties are plateauing out. We should come up with a new great leap forward; further, that we are making the rich richer and the poor poorer; that we have failed because we are unable to get varieties to give high yields on impoverished small farms and low yields on large farms of the fertile bottom lands. Because we have failed, we are widening the gap between the rich and the poor. We should concentrate only on the small farmer and forget about the others. To this I have to say "hogwash". The varieties are scale neutral. Change occurs first with the large or medium farmer who can risk change. It comes only later to the small farmer. He must wait and see and if I were in his boat where a crop failure meant his extinction, I would do the same. But he does change and the country is finally the better for it.

As to the varieties plateauing out in yield, I offer in evidence the experience of Mexico with wheat from 1956 to 1976. Land area devoted to wheat remained fairly stable at the country level and in the high yielding area in the state of Sonora where nearly all the crop is grown under irrigation. Production, however, has continued to climb after the beginning of the dwarf period in the early 1960's despite occasional reductions in acreage because of non-incentive prices for wheat as compared to other crops. Contrast the nearly 5 ton hectare yield in Sonora in 1975 with the present 1.4 to 1.5 ton hectare yields of India and Pakistan where 50 and 60 percent approximately of the crop is under irrigation. Yields in these countries can be doubled in wheat alone on the present acreage. However, strong emphasis will require attention to incentive prices, adequate input supply, application of correct technology, fertilizer and irrigation, better use of varieties in a multiple cropping rotation and better drainage to control salinity. The lack of such support contributes to low yields in these countries. As an example, wheat which follows rice is sown two to three weeks later than optimum because rice varieties are late and are not harvested on time.

One of the serious lacks in most of the developing countries is trained manpower. Organizations are weak because colonial powers, if interested at all, developed research capabilities in the plantation crops, not in the food crops. Massive investments need to be made to provide people with education both at the degree and post degree level and at the applied research level. We in the international centres are attempting to provide some of the latter type training. At the universities there must be greater

efforts to provide more meaningful graduate training. I do not mean to discredit those scientists in the developing world who are uncovering new fields of learning but this is not what the developing countries need today--now.

These countries, because of the lack of trained people, also lack decision makers. People from the developed world often comment on the laboriously slow development of the developing countries and on the face of it they are right. Picture the leader in one such country who has to make decisions on fifty different subjects for every one which must be decided by his counterpart in the developed world. He does it also with the sketchiest of statistical information. I have in mind a young man from one of these countries whom it is my pleasure to know. He is 30 to 32 years of ago. Last year he was asked to order all of the fertilizer needs and all the herbicide and insecticide needs, all of the proper type for one of the largest countries in Africa. Do I hear anyone of that age here who would like to have this responsibility along with the regular duties of Director of Agricultural Research for that country? This is the real world of the developing countries.

One could go on at great length on the difficulties of trying to help the developing countries. Bureaucracy learned from the developed is even more stifling here. Seed production is nearly nonexistent in the majority of countries and where attempts have been made most have been taught a nonapplicable, highly sophisticated form of seed production totally unsuitable to the needs. Land reforms that seek to follow political expediency by people who should and must know that the proposed schemes will wreck the economy. They are totally unrealistic in the sense that the farms are so small they cannot provide subsistence, let alone have a generation of sufficient saleable product that the results are reproducible year to year. Projects are set out, fertilizer is supplied, work is done, results are achieved, the help is withdrawn and the project collapses. This is a scenario repeated year after year often by sophisticated aid agencies with all the goodwill in the world.

Most of the country leaders are generals, lawyers, politicians and almost anyone but farmers. They know nothing about farming, yet their very life and tenure of office is wholly dependent on whether agriculture can be made to produce. There seems no end to problems. Yet things can be done and things are being done!

I refer again to the paper by Wortman (12). In it he gives an optimistic note and I want to impress on the reader that one must have optimism or nothing will happen since the multiplicity of problems can be overwhelming. A start must be made and like taking the first step, the next one follows logically once the first has been accomplished.

Wortman states that the only way to stimulate higher production is to increase agronomic activity leading to better rural income. Some of the encouraging features of the present are as follows:

1. The nature of the problem of agricultural development is better understood.
2. The interconnected complexities of the problem are better understood. The biological part is probably the least understood by planners and leaders.
3. The potential for increasing yields is great.
4. Large amounts of chemical fertilizer are now being made available.
5. Governments have demonstrated they can take effective action if there is a will--India 13 million hectares of high yielding varieties in five years.
6. There is now a functioning network of financial institutions--Inter American, Asian Development, African Development, Common Market Banks.
7. A number of international centres have been established to assist countries to improve yields of various crops.
8. Some governments are showing a determination to develop rural areas.
9. There are still substantial areas to develop.

To have success there must be well organized campaigns using biology and technology, capital and dedication if the health, housing, education, clothing and above all hope of the peoples of the world are to be realized.

We biologists reject the lifeboat theory, the triage theory and the exportation of poverty theory. This is now one world. Unlike the approach that is all too rife in the world, we do not believe in pulling the rich countries down to the level of the poor but to raise the poor countries up to a decent standard of life.

I would like to close with two quotations, one from Peter Jennings (14) and one from David Hopper (10). Jennings says, "The Green Revolution did not solve the problem of world food supply; rather it demonstrated an approach to a solution, a method. That method can be successful only if it is applied continuously to crop improvement." My only comment is that biological systems and their interactions with the environment are ever shifting, ever changing but ready to revert to equilibrium if left for an instant. Man must seek to bend the equilibrium to his favor, not give in to the insects, weeds and natural hazards. Environmentalists, please observe.

Dave Hopper says, "It is important to recognize that the world's food problem does not arise from any physical limitation on potential output or any danger of unduly stressing the 'environment'. The limitations on abundance are to be found in the social and political structures of nations and in the economic relations among them. The unexploited food resource is there between Cancer and Capricorn. The successful husbandry of that resource depends on the will and actions of men."

This, I feel, succinctly expresses the present state of the art. Let there be less people, less pollution and more of the good things of life to enjoy.

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