surpluses, but have tended to increase, notwithstanding the reductions in 1977. In that year 105,000 tonnes of milk powder and 36,800 tonnes of butter oil were made available for food aid compared with 150,000 tonnes and 45,000 tonnes respectively in 1976. As part of its on-going food aid programme the Community also provides emergency food aid from the reserves incorporated in the annual food aid allocations.

89. Proposals made by the Commission in September 1976 for a three year Indicative Food Aid Programme for 1977-79 were withdrawn in March 1977 since some countries were not prepared to accept an increase in the volume of aid. The Programme had emphasised 4 features, viz:-

(i) aid to be planned for a three-year period;

(ii) the volume of aid to be significantly increased during the period of the programme;

(iii) aid to be concentrated on cereals;

(iv) national schemes of aid to be gradually incorporated into the overall Community scheme.

Although the Indicative Food Aid Programme has been withdrawn, it is understood that other ways of improving the Community's food aid policy are still under consideration.

VI. The Provision of Agricultural Inputs

(i) Fertilizers

90. The fall in fertilizer prices at the beginning of 1975 stimulated fertilizer consumption. As a consequence world consumption, which had fallen in 1974-75 by 3.2 per cent, recovered in 1975-76 by 9.6 per cent to a fresh record level of 88.7 million tonnes. This was about 6 per cent above the previous peak of 1973-74. Consumption in developing countries rose by 11 per cent, and was favoured by lower international prices, reductions in domestic prices, and a marked fall in freight rates during 1975. Indeed by 1975-76 the crop/fertilizer price relationship had returned to the pre-crisis level of the early 1970s.

91. Fertilizer consumption in developing countries rose on average by 8.5 per cent between 1969-70 and 1975-76, and is forecast to rise by 10 per cent per annum in the period 1974-75 to 1980-81. However, if the observed ratio between the growth rate of food production and that of fertilizer consumption of 0.23 is maintained until the end of the decade, the implied growth rate in food production would be only 2.3 per cent per annum. Since this is well below the Second Development Decade Target of 4 per cent, it is evident that to achieve this higher rate of food production, substantially higher rates of fertilizer consumption than those currently predicted will be required in developing countries. It is estimated that world fertilizer supplies will be adequate until 1980-81, on the basis of intended expansions in fertilizer production capacity, and the 10 per cent

per annum rise in consumption now predicted for developing countries. However, past experience indicates that developing countries have the capacity to use more fertilizers if supplies are available, and such an increased use is essential if developing countries, particularly the MSA and Food Priority countries, are to raise their grain production by the desired 4 per cent. To meet this requirement might necessitate an annual increase in fertilizer consumption by developing countries of 16 or 17 per cent per annum, somewhat above the average rate prevailing during 1964-65 to 1969-70. This would imply a rise in developing country fertilizer consumption to about 28 million tonnes by 1980-81, which would still be below the estimated fertilizer capacity of these countries of 33.7 million tonnes.

92. This approach, however, greatly oversimplifies the problem for several reasons. In the first place fertilizer plants in developing countries are, for a variety of reasons, frequently operated below capacity. It cannot be assumed that developing countries as a group will be capable of meeting all their requirements in the next five or ten years at the higher rates of consumption postulated. Furthermore, although fertilizer capacity has increased significantly in certain developing countries, for example India and Bangladesh, and other developing countries may shortly have supplies available for export, geographical and economic factors would not permit all the fertilizer requirements of developing countries collectively being met by production in developing countries. It is in the Food Priority and MSA countries where the need for increased fertilizer production and consumption is greatest; the mere availability of adequate fertilizer supplies on world markets at normal prices is of little value to the MSA countries if they lack the financial resources for their acquisition. These countries will therefore continue to look to the international community for assistance, either bi-lateral or multilateral through the International Fertilizer Supply Scheme (IFSS), for the provision of the necessary fertilizers.

93. Bi-lateral assistance towards the provision of fertilizers has fallen off since the crisis years of 1973 and 1974, and such aid in 1976-77 was only 74 per cent of that provided in 1974-75. The multilateral operations of the IFSS (plus very small supplies provided by the EEC) constitute only a small part of the fertilizer assistance given to MSA countries and it is from bilateral sources that the bulk of fertilizer resources for MSA countries has come. The measure of the failure to provide MSA countries with sufficient fertilizers is illustrated by the fact that at its 1975 meeting the World Food Council recommended that 1 million tonnes of plant nutrient should be provided at the bilateral and multilateral levels to enable MSA countries to obtain their required plant nutrients; in fact the total quantities provided in 1974-75, 1975-76 and 1976-77 were 570,000 tonnes, 540,000 tonnes and 430,000 tonnes, respectively. Of these only 11 per cent on average were provided through the IFSS despite a recommendation by the Group of 77 to the 1976 meeting of the World Food Council that at least 30 per cent of fertilizer aid should be channelled through the IFSS. The requirement of 1 million tonnes of fertilizer nutrients for the MSA countries was re-stated at the 1977 meeting of the World Food Council, but there seems little likelihood of this aim being achieved. The estimated total import requirements of the MSA countries in 1977-78 have been put at

2.38 million tonnes of plant nutrients; on present indications it appears unlikely that more than about 500,000 tonnes of plant nutrients will be available on aid terms, leaving the MSA countries to bear the cost (some $600 million) of the remaining 1.88 million tonnes themselves.

94. Since fertilizer consumption in the MSA countries in the biennium 1974-75 and 1975-76 showed an annual average growth rate of only 3.4 per cent, despite the fall in prices and the improvement in world supplies, it appears that the fertilizer crisis of 1973-74 is persisting in MSA countries, although it has changed in nature. Analysis of the MSA countries' requirements in 1977-78 by regions indicates that although Asia would need to import 1.41 million tonnes of plant nutrient it would nevertheless provide 71 per cent of its overall requirements of 4.85 million tonnes; Latin American MSA countries required only 265,000 tonnes, but would have to import some 240,000 tonnes, more than 90 per cent of requirements. The 28 MSA countries in Africa were estimated to require 1.08 million tonnes, of which 0.73 million tonnes, over two-thirds of the total, would need to be imported.

95. No easy solutions to the fertilizer problems of the MSA countries can be envisaged. The IFSS, which is now to be prolonged for another two years, was conceived in a period of acute shortages and high prices, and lacks the resources to fill the gap between MSA country requirements and their limited import ability. (Indeed, in future the IFSS will intervene primarily to maximise the economic impact of its fertilizer supplies on the agricultural sectors of the recipient MSA countries, while also offering short-term consultant and follow-up assistance advice). Specific requests by recipient countries for additional quantities of fertilizer might increase the flow of concessional supplies somewhat, especially if the next few years see some tendency to world over-supply and a weakening in prices. It is predicted, however, that after 1980-81 prices may need to rise to attract new investment in fertilizer plants in which case MSA country problems will be intensified.

96. Two particular aspects of the fertilizer situation merit further attention. The first is that timely imports of essential fertilizers are much more economic than subsequent imports of food. This suggests that some part of food aid might perhaps beneficially be converted into fertilizer assistance. There are evident difficulties, since the greater part of food aid (much of it consisting of surpluses) is already ear-marked for development purposes. But if donor countries could be persuaded that fertilizer aid was a far more effective form of aid than food aid it might in time prove possible to use at least part of the cash provided for food aid for the purchase of fertilizers for MSA countries. Other possibilities may exist for triangular trade, with food aid being made available to developing fertilizer exporting countries in return for fertilizer deliveries to MSA countries.

97. The second aspect concerns the circumstances in which it would be practicable and economic for developing countries, including MSA ones, to build fertilizer plants rather than import fertilizers. Clearly a large number of new fertilizer plants are being constructed in developing countries since, according to the CGFPI, commitments for fertilizer plants increased from $90 million in 1973 to $1,382 million in 1975, and may have increased further in 1976. World Bank assistance for fertilizer plant construction has increased significantly, since between 1961 and 1973 the Bank provided only $140 million to help finance fertilizer plants whereas in 1974 $329 million was provided and in 1975 $434 million. Nevertheless, the construction of new fertilizer plants requires both convenient access to raw materials

and the provision of an adequate infrastructure. Developed countries and some of the more industrialised developing countries already posses infrastructures requiring little modification or adaptation for the establishment of fertilizer plants, but the construction of similar plants in the least developed countries, especially if built on remote or "green field" sites, would necessarily require the establishment of substantial infrastructures, which would therefore be an important part of the project cost. On this basis many developing countries, notably the MSA ones, would be faced with such high production costs that it would almost certainly be more economic for them to import their requirements than manufacture them. It is for this reason that recent investment in fertilizer plants in developing countries has been mainly in those with well-developed infrastructures such as India, Pakistan, Brazil and Indonesia, or in OPEC countries,which have the required raw materials and can also afford to incur high construction costs.

98. In the context of construction costs it is significant that none of the African MSA countries except Egypt, and, to a lesser extent, Senegal have the capacity at present to produce nitrogen or phosphate fertilizers. In the Asian MSA countries, these fertilizers are produced in large quantities only in India, Bangladesh and Pakistan, which have established infrastructures, while there are little or no production prospects in the MSA countries. With regard to future production prospects in the MSA countries, although the developing countries' capacity for the manufacture of nitrogen is likely to double between 1976-77 and 1981-82, it does not seem likely that much of this will take place in the MSA countries of Africa or Latin America because of high infrastructure costs and limited raw material supplies. The position is rather different with regards to phosphates, since by 1981-82 the supply from developing countries is expected to more than double on account of increased output in Africa and the Far East; the only MSA countries likely to participate in this increase on a significant scale, however, are Senegal and Egypt. MSA countries do not produce potash, nor for that matter do other developing countries apart from Congo and Chile, so that in the future developing countries will have to continue to import most of their potash requirements.

99. An important feature of fertilizers is that their supply lends itself to regional approaches. Examples of regional cooperation arrangements are those of the Andean Group, the Latin American Economic System (SELA),the Senegal River Development Organisation (OMVS), the Industrial Development Centre for Arab States (IDCAS), and ESCAP. A Commonwealth initiative in regional cooperation in fertilizer supply is being undertaken in relation to the ECOWAS group in West Africa, while a regional Commonwealth fertilizer project for the Caribbean is also being studied.

100. During 1976 the FAO Commission on Fertilizers concluded that an international commodity agreement for finished fertilizers would probably not be a feasible proposition, although it requested the study of long-term contracts, particularly with regard to enforcement procedures; the FAO Council at its meeting late in 1976 broadly concurred with the Commission's views. However, it felt the study of international commodity agreements regarding fertilizer raw materials should continue, especially since phosphates have been included in UNCTAD's Integrated Programme for Commodities.

101. Preliminary data for 1976-77 (July-June) reveal a continuation of the recovery in world fertilizer consumption which began in the previous season; indeed the annual increase between the two seasons came back into line with the average growth rate of the past ten years. While all regions participated in the increase, growth was highest in the developing

countries, which appear to have consumed slightly more than in the peak year of 1973-74. The general rise in consumption was favoured by lower world fertilizer prices and by improved crop/fertilizer price relationships. The relative stability of fertilizer prices in 1976 was not maintained in 1977, when some strengthening of demand led to higher prices for nitrogenous and phosphatic fertilizers; the early months of 1978 were also characterized by generally firm prices. World supplies of the three primary nutrients in 1977-78 appear to have been adequate, but certain MSA countries continued to have difficulty in covering their import requirements owing to balance of payments difficulties.

(ii) Pesticides

102. Resolution X of the World Food Conference called for international co-ordination of the supply of pesticides and for advice on their use. An ad hoc Consultation on Pesticides in April 1975 recommended an improved information system; an expanded emergency fund; increased formulation and manufacture and expanded training schemes in developing countries. A Resolution of the Group of 77 at the 1976 Meeting of the World Food Council called upon FAO to organise within the International Fertilizer Supply Scheme assistance to MSA countries suffering from acute pesticide shortages and invited contributions of about $20 million for this purpose.

103. High prices slowed down the use of pesticides in 1975-77, although developing countries' usage still increased by 9 per cent each year. Other limiting factors on pesticide use are the training of technicians and the complex infrastructure required. The main difficulties with regard to supply are that the old, well-established, tried pesticides, still valuable in developing countries, have been supplanted in developed countries by more costly, specialised pesticides on environmental grounds or because of growing insect immunity.

104. Because they are expensive and require sophisticated infrastructures specialised pesticides are not in use much in developing countries, where the demand is still for traditional pesticides. The latter to some extent now have to be manufactured in developing countries owing to restrictions on manufacture in developed countries. Shortages of traditional pesticides developed in 1976 to such an extent that assistance with their supplies was extended to certain developing countries. Nevertheless, pesticide use remained low in many developing countries during 1976. Since it is calculated that losses from pests, diseases and weeds average 30 per cent on some crops, it is vital that pesticide use should be accelerated in developing countries. There seems to have been no significant response to the appeal of the Group of 77 for $20 million to provide MSA countries with pesticides. At the 1977 Meeting of the World Food Council it was recommended that international agencies and donor countries should give special financial and technical assistance to developing countries suffering from shortages of pesticides and weak plant protection services. If, as seems likely, the response of the international community remains weak, affected countries might apply to IFAD for assistance in procuring pesticide supplies and/or in the construction of pesticide plants. As with fertilizers, there is probably scope for the production of pesticides on a regional basis.

105. During 1977 world pesticide production appears to have risen by 5-10 per cent, so that, in combination with an improvement in the stock position, supply was adequate to meet demand. Prices generally remained stable during the year, and the main problems for several developing countries continued to be the lack of foreign exchange for the purchase of requirements and a shortage of trained personnel to supervise the introduction of new varieties. Currently the demand for herbicides is growing more rapidly than for pesticides or fungicides.

(iii) Improved Seed Varieties

106. In response to Resolution XII of the World Food Conference, an Expert Consultation on Seed Industry Development, held in December 1975, formulated a global seed production training programme. The Seed Industry Development Programme (SIDP) has identified projects for national development, but lack of funds has hindered development. As with pesticides, so the Group of 77 in 1976 pressed for more action on seed industry development, calling on FAO to strengthen the SIDP, and requesting the International Rice Research Institute (IRRI) to develop further its work on the identification of high-yielding varieties; at the same time there was an appeal to donor countries to provide $20 million to SIDP and IRRI for their enlarged activities. The call for improved seed varieties was re-iterated at the 1977 meeting of the World Food Council, which recommended that international research institutes should co-operate with developing countries in the search for new high-yielding varieties. The Council also called for developing countries to be supported through bilateral programme or voluntary contributions to SIDP to an amount of at least $20 million.

107. The provision of improved varieties of seed is the third aspect of the package of improved inputs required to increase food production in developing countries. Not only is good seed vital to a high level of crop production, but the development of high-yielding cereal varieties is an on-going process, requiring constant research, since new varieties of seed are frequently high-yielding only for a limited period before other natural factors tend to reduce their yields. Surveys show that under a fifth of developing countries use HYVs on a large scale, and of these only one-third had established adequate seed multiplication services. Seed supply is inadequate in many countries, and there is also a need for equipment and trained personnel.

108. The international institutional framework for seeds is already functioning, and the problem is basically that of establishing seed industries in developing countries. Since modest seed projects can be established at a relatively low cost, it would seem that the provision of the $20 million for seed development by the international community would go a considerable way towards helping increase food output in developing countries. The supply of essential equipment and of trained personnel would probably be a first call upon resources, a fair proportion of which might come from IFAD or bilateral donors. To guard against disasters seed reserve stocks should be established, probably on a regional basis.

109. In general the regional approach to the provision of improved seed varieties is likely to have its limitations owing to the fact that different areas within a region may require the development of their own varieties of seed. Nevertheless, there could be opportunities for certain facilities to be centralised, while leaving other work to be carried out at the local level but with an abundant exchange of information between all centres.

110. An area that requires more attention and resources is the development of new high-yielding varieties for traditional local crops other than rice or wheat. Local crops to which the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), for instance, is giving special attention include sorghums, millet, chickpeas and pigeonpeas, while the International Institute for Tropical Agriculture in Nigeria is working on cowpeas, soya beans, lima beans, cassava, sweet potatoes and yams.

(iv) Farm Machinery

111. The term "farm machinery" covers a very wide span of equipment, ranging from simple hand-operated appliances or tools, through motors to power appliances such as threshing machines or to operate pumps for irrigation purposes, to tractors for mechanical cultivation. The criteria for the effective use of machinery in developing countries are different from those applied in developed countries, since in the latter machinery is intended to maximise output per worker, whereas in developing countries land constraints generally demand that machinery should maximise the output per unit of land and should be labour-intensive. Machinery that displaces labour, adding to the number of rural unemployed, has little place in developing countries; the use of machinery should be determined by the requirement that it should increase yields of food crops, reduce costs, or permit the undertaking of operations which would not otherwise be possible. Unfortunately tractors are often considered the most important kind of farm machinery, whereas in fact less complex and cheaper equipment is potentially of much greater use to small-scale farmers. Indeed, the use of tractors, per se, appears to have little effect on crop yields, at least in Asia, where their use is associated with other yield-increasing inputs, which are often of greater importance. The main advantage of tractor usage is that in some circumstances it saves time and therefore permits an improved cropping programme, leading to a further demand for labour.

112. Where the peasant farmer is concerned, however, the provision of simple mechanical appliances, permitting an improvement in yields, should be the dominant consideration. Along with these should be considered machines that facilitate tasks that would otherwise be carried out inadequately or not all (e.g. the placing of fertilizer in the root zones), or which speed up the tempo of operations so that time is available for the cultivation of additional crops. Other important examples of desirable machinery are the motors or engines required to pump water for irrigation purposes; these may be considered part of the function of irrigation rather than as farm machinery, but they may also be used to drive equipment such as rice hullers, sugar cane crushers or stationary threshers, or even to carry out simple food-processing operations such as rice cleaning and polishing.

113. Although the international community has perhaps laid less stress on the provision of farm machinery in recent years than on the supply of other inputs, nevertheless the World Food Council at its 1977 meeting recommended that "irrigation equipment and selective and appropriate implements for mechanisation" should be provided as parts of a minimum package of inputs by donor countries and international agencies on concessional terms to Food Priority Countries.

114. Since much farm machinery is probably supplied as parts of projects or programmes it is not possible to put any precise value on the requirements of developing countries. According to the CGFPI the annual average value of external capital commitments to agriculture of machinery and other inputs (excluding fertilizer supplies) in 1974 and 1975 was $68.2 million out of a total of $4,403.8 million. Commitments to machinery (all bilateral) were thus quite small, although some other commitments for farm machinery might well have been made under other headings such as crop development. Even

when allowance is made for the likelihood that in many developing countries, notably the MSA ones, the number of tractors may not greatly affect crop yields, and therefore requirements are low, the accompanying table shows that developing countries account for only 10 per cent of all agricultural tractors in use and for only 5 per cent of harvester - threshers. If anything like similar proportions exist for simpler types of agricultural machinery it is clear that developing countries must have an extremely large potential to use simpler equipment, some of which could no doubt be produced by moderately industrialised developing countries

Table J - Agricultural Tractors and Harvester-threshers: Numbers in Use in Developing Countries and in the World

(thousands)

	Agricultural tractors				Harvester-threshers			
	Av. 1961-65	1973	1974	1975	Av. 1961-65	1973	1974	1975
Developing countries	703	1,466	1,585	1,706	102	138	143	149
World	12,410	16,463	16,904	17,212	2,257	2,686	2,758	2,878
Developing countries as a percentage of world total	5.7	8.9	9.3	9.9	4.4	5.2	5.2	5.2

Source: FAO Production Year Book, 1976.

(v) The Reduction of Post-harvest Losses

115. The Seventh Session of the General Assembly of the UN stressed that a major effort should be aimed at the "reduction of post-harvest food losses in developing countries.... as a matter of priority.... reaching at least a 50 per cent reduction by 1985". All countries and international organisations were asked to co-operate in achieving this objective. At the Second Session of the World Food Council (1976) the Group of 77 called on FAO and governments to assess harvest and post-harvest losses and take measures to reduce them. The Group of 77 also invited donor countries to contribute some $20 million to a trust fund in FAO for work in this area. Following a study in depth of the matter by the FAO Committee on Agriculture in April 1977, the Third Session of the World Food Council recommended that "in supporting the food production efforts of developing countries, programmes should be initiated by them and supported by appropriate international agencies and bilateral donors to reduce harvest and post-harvest losses, and to this end FAO's activities in this field should be substantially

strengthened". Harvest losses, both pre-harvest and post-harvest, were discussed at the Session of the FAO Conference held in November 1977.

116. Estimates of post-harvest losses vary enormously, even as between the different stages of the post-harvest system. There are mechanical losses during harvesting, drying, handling and processing, which in the case of food grains are probably in the range of 5-10 per cent. Biological losses are normally at least 10 per cent, more in some countries, of the actual yield of food grains. For other foodstuffs losses are generally greater. In respect of the proportion of crop actually lost, the vital significance of reducing post-harvest losses (or more positively of increasing the proportion of the harvest delivered to the consumer) may be simply illustrated with a single example. It is forecast that by 1985 the cereal deficit of developing countries (excluding cereal exporters) will be in the region of 100 million tonnes. The cereal production of developing countries in the same year is projected to be some 850 million tonnes. Thus a 10 per cent reduction in post-harvest losses would to a large extent eliminate the projected cereal deficit, a 12 per cent reduction entirely so.

117. In this perspective the reduction of post-harvest losses can be seen to be as important as current efforts to increase food yields in developing countries. Up till now plant scientists may be said to have done more for the welfare of the developing world than those concerned with post-harvest systems, and it is clear that the success which has attended efforts to increase food production in developing countries needs to be accompanied by corresponding improvements in the quantity and quality of grain delivered to consumers. Indeed it could be argued that effective measures to prevent food waste after harvest have a more vital role in increasing food supply than further efforts to raise output, since in the absence of such post-harvest measures a large part of the increase in food production will automatically be lost. However, such a view of the matter is unbalanced, since measures to increase food production and reduce the proportion wasted complement each other, and should therefore be undertaken simultaneously.

118. The problems of attempting to reduce post-harvest losses lie in the fact that there are a wide variety of loss-causing factors, the influence of which will vary from crop to crop and from country to country; furthermore these factors themselves will be affected by methods of production, forms of storage and methods of marketing. In addition it is very difficult indeed to identify the factors causing greatest loss, and the stages at which losses occur. Lastly, not only is there the problem of physical loss, but in many cases there is also a nutritional loss which may not readily be apparent. Thus it appears that workers in the post-harvest system face a far greater number of unknowns than do those dealing with other aspects of increasing food supplies.

119. Loss prevention can be seen in terms of three major constraints. Firstly, there is lack of information at all levels, but especially at the level of the small farmer, of the magnitude of losses, their causes and remedies. Secondly, there is the lack of infrastructure, as exemplified by trained personnel, the organised establishment of extension, technical and research services, pesticide availability, credit facilities and legislation, etc., to enable the implementation of loss prevention measures. Lastly, there is a

lack of investment in food loss prevention measures which is likely to be greater than in other areas of raising food supply since the need for such measures is often not very evident, nor can a substantive return on them be demonstrated. As with other aspects of food production, it is difficult to measure the resources, internal and external, devoted to the prevention of post-harvest losses in developing countries, but in 1974 and 1975 annual external aid commitments, bilateral and multilateral, to crop storage and processing in agriculture were $90 million, of which about three quarters was in the food sector. Even if some of the substantial external commitments under other headings such as rural development and general agricultural development also contain some provision for the reduction of post-harvest losses it appears that external investment in this field is inadequate.

120. This view was endorsed by the FAO Conference in November 1977 which recognised that while activities to prevent pre-harvest losses had been broadly in balance with attempts to increase food production post-harvest problems of grains had seldom received the attention they invited. Noting the need for widespread national 'Save Food' programmes, FAO has formulated a priority programme to reduce food losses of staple foods in LDCs, MSA and FPCs. Since the funds required to implement all national programmes will involve several hundred million dollars, it is extremely doubtful if post-harvest losses can be reduced by 50 per cent by 1985, as is the aim. Nevertheless the FAO proposal that a Special Fund of $20 million should be established for post-harvest programmes has been approved; it is suggested that $10 million should be transferred from the FAO 1976-77 Suspense Account, while countries are to be invited to provide the balance.

121. An associated aspect of post-harvest losses is the provision of adequate grain storage facilities. The relationship is really two-way. A reduction in post-harvest losses can be expected to increase available supplies of grains, thereby adding to the requirements for storage facilities. Similarly, improved storage facilities will of themselves tend to reduce post-harvest losses.

122. This matter will be dealt with more fully in a companion paper on world food security. It is sufficient here to note that financing of grain and other food storage facilities is beyond the capacity of many developing countries who will therefore need look to the international community for help. Financing storage facilities is a bankable proposition and assistance could be sought from the IBRD and regional development banks. For the least developed and MSA countries concessional assistance both to reduce post-harvest losses and for the provision of storage facilities might come from IFAD, the World Food Programme (WFP) or from the International Development Association (IDA). There are possibilities for the co-financing of measures to reduce post-harvest losses by the FAO Special Fund and other agencies, while international and bilateral agencies could co-finance the provision of additional storage facilities.

123. As with fertilizers and pesticides, there are probably important opportunities for regional co-operation in the reduction of post-harvest losses, since neighbouring countries with broadly similar agricultural economies and climatic conditions should be able to pool experience and, to some extent, facilities. In this connection, mention may be made of the Regional Worshop on Post Harvest Losses sponsored by the Commonwealth Secretariat, which was held in Accra in April 1977. In addition to the four Commonwealth countries which participated in the Workshop there was also representation from the Ivory Coast, Mali and Senegal. One of the recommendations of the Workshop, noting that there was scope for inter-country co-operation in West Africa, was that there should be (i) movement of personnel between countries, (ii) a regional centre for the dissemination of information (ECOWAS, FAO, or IITA were logical starting points), and (iii) that agencies should devote more of their resources to an integrated and co-operative effort.

(vi) Research, Extension and Training

124. The World Food Conference stressed the need for increased emphasis on research, extension, education and training as vital elements in plans for increasing food production. The importance of research is underlined by the fact that it has been claimed that expenditure on research in developing countries provides 2 to 3 times as much growth as can be attained from any other form of investment.[1] Thus research is likely to pay handsomely.

125. Three types of agricultural research as regards developing countries may be distinguished. Firstly, there is national research in the countries concerned. This is the most important quantitatively, and the most likely to yield significant returns for the countries concerned. In developing countries this kind of research is almost always undertaken in the public sector, apart from any carried out by multinationals, most probably in respect of staple export crops. Secondly, there is the research undertaken by the international research institutes under the aegis of the Consultative Group on International Agricultural Research (CGIAR). Since the World Food Conference the number of specialist international research centres has increased to eleven, of which the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Centre (CIMMYT) may be cited as two of the oldest established and most successful. The third form of research is that by developed countries undertaken in or on behalf of developing countries. Very roughly, the levels of expenditure in these three areas of research activity in 1970 (at 1970 values) have been estimated as follows:-

(i) national public sectors in developing countries $235 million;

(ii) international research centres $10 million; and

(iii) by developed countries on behalf of developing countries $115 million.

This gives an approximate total for the three types of research of some $360 million.

126. Agricultural research has played a major role in more than doubling the grain yields of developed countries in the past four decades, and, to the extent that the "Green Revolution" has achieved success in developing countries, the vital role of agricultural research must be acknowledged. It has been estimated that in 1970 out of a total world public sector expenditure on agricultural research of $1,560 million, only $235 million, or 15 per cent, was in developing countries. Furthermore, it was calculated that

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[1] Investment in Agricultural Research, Robert Evenson, Yale University, October, 1973. Quoted in The World Food Problem, E/CONF.65/4 (1974), Chapter V.

developing countries only spent on average 0.25 per cent of their agricultural GDP on agricultural research, whereas the average for developed countries was 1 per cent, and for some the proportion was as high as 2 per cent.

127. Two features emerge very clearly from these figures. In the first place developing countries will need to increase their expenditure on agricultural research very substantially if they are to achieve the increases in yields which are vital to raising their food production. Secondly, in an area which is of vital importance, the developing countries are spending least on research, although increased research spending would almost certainly yield higher returns than elsewhere in the world.

128. The need for increased agricultural research is greatest in the developing countries themselves. Although the spotlight in recent years has been on the international research centres financed by the Consultative Group on International Agricultural Research, the great bulk of research on developing countries' agricultural problems needs to be carried out at the national level. This is because agriculture is largely location - specific, and in general plant varieties cannot easily be transformed from one climatic zone to another. There are exceptions to this rule such as hybridisation, but nonetheless the best results are obtained where plants have been developed for rather limited geographic areas. Differences in rainfall, altitude, length of day, length of growing season, and temperature ranges are frequently critical, and appropriate varieties of plant need to be evolved to meet local conditions. There is also the question of biological resistance of plants to local diseases and insect pests. Frequently plant varieties developed successfully for certain areas are found to succumb to new plant diseases and insect attacks when transferred to other regions. Even when new varieties of plant can on occasions be successfully transferred from one area to another, applied research is still required at the national level to evaluate the success or otherwise of the transfer, and to explore further possibilities of plant development.

129. What are the costs of the successful development of national agricultural research institutes likely to be? It is unrealistic to cost the establishment of an ideal system, since for many countries, even with elements of concessional assistance, such costs could not be borne. At the World Food Conference it was suggested that between 1970 and 1985 developing countries should aim to increase the proportion of their agricultural GDP devoted to agricultural research from 0.25 per cent to 0.50 per cent. On the now somewhat questionable assumption that agricultural production in these countries would rise by 4 per cent annum, it was estimated that developing countries by 1985 would have annual resources of $900 million (in terms of 1970 dollars), from their own budgets to finance agricultural research. Compared with 1970 this would have represented a near quadrupling of resources. In fact a more realistic assumption of only 3 per cent per annum growth in agricultural production up to 1985 results in only $780 million being available for research by 1985, roughly three times the 1970 sum. World-wide inflation, both past and prospective, renders these figures of little value in present day conditions, but it may be reasonably concluded that to reach significant levels real expenditure on agricultural research by developing countries by 1985 needs to be increased at least three-fold, but preferably four-fold, as compared with 1970.

130. It is doubtful whether present expenditure on research at the national level is increasing at anything approaching the desired rate. Apart from the provision of buildings, plant and equipment, one of the biggest obstacles to increasing research in developing countries is the shortage of trained personnel, and here developed countries could make a valuable contribution by training many more scientists. But beyond this what is required even more of developed countries is a long term commitment to support agricultural research in developing countries. A not unreasonable target might be for developed countries to make available, say, half a billion dollars each year for the next decade to support agricultural research in developing countries. Alternatively, developed countries might undertake to put up for agricultural research over a number of years the same amount as developing countries themselves actually devote to agricultural research.

131. The international community has responded fairly generously in the last few years to the research requirements of the new regional research centres supported by the CGIAR, which in turn is sponsored by FAO, the World Bank, the UNDP, and a number of national governments, regional organisations and some private foundations. Compared with 1972 when only about $15 million was used to fund the operations of the five research centres, expenditure by the Group in 1976 at its 11 centres was $64 million, while the budget for 1978 is some $88 million. Although regional research centres are important, and the two which have been in existence for a long time have high-yielding Mexican wheat and semi-dwarf rice, important elements in the "Greeen Revolution", to their credit, their importance may have been over-emphasised in recent years at the expense of national research centres. The main advantages of these centres are the calibre of the staff they can attract and the scale of operations they can undertake. On the other hand they are expensive to run, in terms of scientist-man-years, and the same expenditures in national research systems would provide for twice as many scientist-man-years. For this reason it is suggested that expenditure on these centres (or on new ones) should not be expanded in real terms very much more between now and 1985.

132. Nevertheless, the present limitations of the international research centres are leading to intensive investigation as to how the agricultural technologies developed in these centres can be successfully transferred or adapted to the frequently very different economic, ecological and climatic conditions prevailing in the developing countries. The CGIAR is giving the matter considerable attention, and a partial solution of the problem evolved by some of the centres has been to move some of their work to national research systems through "outreach" programmes and technical assistance projects. In this way the innovations and improvements originated in the centres can be tested in and adapted to the local conditions in different developing countries. For these transfer techniques to be successful, however, requires the host governments to provide other complementary services, a task frequently beyond the capability of LDCs and the MSA countries. It has also been suggested that because of the disparity between the resources of the international research centres and the national ones, there should be more linkages between the work of the two types of centre in matters such as research training, seminars, identification of priorities, and farming systems. Such developments are likely in the next few years.

133. Research expenditure in developed countries on behalf of developing countries was estimated at about $115 million in 1970. The World Food Conference suggested that this figure might be increased to $200 million or $250 million by 1985 (these were 1970 values, and should certainly be at least doubled to take account of recent inflation). There is a lack of

information about current levels of agricultural research work being undertaken in or by developed countries on behalf of developing countries. The shortage of funds for the establishment of new research centres in developing countries, occasioned by the present depressed state of the world economy, may have been accompanied by a greater readiness by developed countries to undertake projects on behalf of developing countries in their own research centres. In this way under-utilised capacity may be more intensively used, employment of scientific personnel may be increased and opportunities to train staff for developing country research institutes can be expanded. Some of the more "advanced" research work such as post-harvest technology, the development of pesticides, and processing of food crops, can probably be handled capably in developed countries, and at a relatively low cost compared with the heavy capital costs likely to be incurred in establishing new research centres in the developing countries. Thus, in order to keep their aid budgets lower than they would otherwise be, developed countries may increase their expenditure of this type quite considerably. In short, the work undertaken by developed countries on behalf of developing countries may be very valuable and cost-effective, but it may also represent an attempt by developed countries to evade the greater financial demands that would arise were they to undertake to support more direct agricultural research in developing countries.

134. Whenever research is undertaken, it is probably true to say that it usually takes far too long for the results of research to reach the farmer in developing countries. Here the efficiency of the extension services is critical. Not only is it essential that there should be adequate numbers of competent personnel to pass new knowledge on to peasant farmers, but it must be demonstrated to farmers that the practical application of the results of research to crops is a paying proposition. If necessary, assistance should be made available (on a short-term basis) to farmers to enable them to take advantage of the results of applied research. In this way they will learn that the results of research, when properly applied, also bring financial benefit to themselves as well as an increased supply of food to the community. If small farmers are convinced of the superiority of new forms of production, with their consequent economic benefits, then experience suggests that they will adopt the new techniques of production willingly and rapidly.

135. A weakness of agricultural research until quite recently has been an over-emphasis on export crops at the expense of basic foodstuffs. Since the world food crisis of 1973-74, however, there appears to have been a conscious attempt to direct a larger proportion of research expenditure specifically to improving the output of food crops. Even within the context of increased research expenditure on food, there is still a need for further diversification. Up till now the bulk of research has been done on grains, but the time is now approaching when some fundamental research should be directed to root crops since these are the staple diet of about a tenth of the world population. An enormous area of Africa would become available to increase world food production if the tsetse fly could be eliminated from Central Africa. The development of a tsetse fly control programme could be undertaken by international agencies in co-operation with developed countries, with the actual implementation of the programme being undertaken by affected developing countries supported by resources of the developed world. A most promising area for the application of research in the post-harvest stage is fish, both in its preservation and processing and in the adaptation of unfamiliar species for human consumption.

136. The need for adequate extension services in developing countries has already been stressed, and it is evident that the training of more staff and an expansion in extension services in most developing countries is a matter of the utmost urgency. Nevertheless, studies[1] indicate that developing countries, in terms of extension workers per dollar of production, have a relatively high investment in extension activities. Unfortunately this is matched by the low level of resources devoted to research. There is reason to believe that substantial extension services linked to weak research systems have not been very productive. This underlines the need for the research services in developing countries to be strengthened.

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[1] Investment in Agricultural Research and Extension: A survey of International Data, R. Evenson and Y. Kislev, Yale University 1975.