FOOD AND DEVELOPMENT

The Political Economy of Hunger and the Modern Diet

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WWF

KOGAN PAGE

Chapter Four

The Green Revolution Revisited

> Biotechnology is going to make a major contribution to feeding the world over the next 50 years providing we get our regulatory act together. . . .If you look at the world population and what is projected for it in the next 40 years it's projected to double and we haven't got very much more new agricultural land left so there's got to be some extra technology that contributes to producing crops to feed all those hungry mouths. I think biotechnology can be a major contribution there providing that we let it and providing that society, governments and industry can work together in making it happen. . . .We're in the business to make money. A lot of the Third World can't afford to buy our first wave of products. We hope that in the second wave that our products and our ideas and technology can be transferred either directly to the Third World or through those breeding institutions that support them.
>
> (Dr. Ed Dart, Research Director, ICI Seeds. BBC2 *Horizon* Mon. 12th Feb. 1990, 8.10–9.00 p.m.)

This chapter is about the relationship between technological change, food production and hunger. Specifically it is about the Green Revolution – the introduction by Western agencies of high yielding wheat and rice varieties into Third World agriculture in the 1960s and 1970s. Thus, Green Revolution technology is certainly not new. Yet the quotation above illustrates that the basic question whether or not technological change in Western agriculture can be transferred to the Third World with the effect of feeding the hungry remains as relevant in the 1990s as it was in the 1960s.

In chapter 3 it was argued that people do not go hungry because of overpopulation at either a global or a regional level. The other side of the food/population equation is food production. Clearly the view of ICI's senior research staff is that the tranfer of new agricultural technology is necessary to feed the hungry because without it future food production may not be able to keep pace with population growth. Hunger, it is argued can be reduced by making society fit the new technology. For Ed Dart it is not population growth that must be reduced but rather Third World food production that must be increased. But it was also noted in chapter 3 that the world comfortably has the resources to feed all its people. Indeed, in 1986 the British farm minister at the EEC was proposing that British farmers should be paid to take farmland out of production in order to reduce the EEC's surplus of 15 million tonnes of unsaleable grain.[1] However, the problem of ensuring adequate food production at regional levels can be viewed as a separate matter. The central concern of this chapter is the contribution the Green Revolution has made to food production in Third World regions and what this is likely to imply, if anything, for the welfare of people in the Third World and the reduction of hunger. Fortunately in 1990 we have the benefit of considerable hindsight regarding the Green Revolution and so there is the opportunity to apply some of the insights gained from that experience of technological change. It is in this spirit that the Green Revolution deserves a revisit.

4.1 Focus and Definition

Technologies are rarely developed and applied without a purpose or set of goals in mind. In general it may be said that technologies and social relations are intimately linked, with the former nearly always associated with changes in social relations. It is with this in mind that the term Green Revolution is used in this chapter to embrace both the technology and the development strategy underpinning its proliferation and application. Some authors use Green Revolution to refer to the general process of major technological changes in cropping techniques throughout history.[2] This is a perfectly legitimate approach but too unspecific for the purposes of this chapter. Here we shall concern ourselves solely with the wheat and rice varieties tranferred from the West to the Third World in the 1960s and 1970s and some of their major consequences.

As early as 1941 discussions took place between the US and Mexican governments concerning the virtues of a scientific mission to encourage the development of agricultural technology. This resulted in a cooperative venture, starting in 1943, between the Rockefeller Foundation (a US philanthropic organisation) and the Mexican government which set in motion a plant breeding programme resolved to increase the yield of corn and wheat and produce a wheat variety resistant to rust diseases (i.e. plant diseases caused by parasitic fungi that produce reddish spots on stems and leaves). For the supporters of this initiative the official objectives were: (a) to increase crop yields allowing for an increase in food production without expansion of supposedly scarce agricultural land in the Third World; and (b) the reduction or elimination of hunger. However, critics of the Green Revolution, such as George, have suggested that the Rockefeller Foundation's motivation to support the development of the high yielding varieties (HYVs) was influenced by its financial links with transnational companies which would provide the fertilizers and pesticides needed for the new seed varieties.[3] Even assuming this is true, the official objectives are likely to have been real as well as rhetorical for many of the scientists and governments who also supported the project and, therefore, should be retained as a reference point by which to judge the success of the 'mission'.

The Mexican programme was by no means novel. For example, in 1910 the Japanese, in the process of colonising Taiwan, initiated the 'Native Rice

Improvement Programme' in an attempt to produce rice varieties suitable for the Japanese market. A Taiwanese sturdy drought-resistant red rice was eradicated because it was unacceptable to the Japanese consumer and new varieties, requiring deep ploughing and up to a 254 per cent increase in artificial fertilizer, were introduced.[4] However, the Mexican cereal programme *was* exceptional in its success at increasing national yields – from 686 kg per hectare in the late 1920s to 2415 kg per hectare in the late 1960s.[5] But the new technology was not without problems. The HYVs were developed under government funded controlled irrigation programmes which 'replaced' flooding in North-West Mexico. Yet without flood alluvia plant nutrition diminished and so the HYVs tended to require artificial fertilizer. This created an additional drawback – optimal use of fertilizer with rust resistant HYVs caused the ears to be too heavy and the plant would keel over under the strain. It was not until 1954 that a short stocky rust-resistant wheat variety capable of producing high yields under controlled irrigation was developed.

Success in Mexico encouraged the Ford and Rockefeller Foundations to spend $7.4 million for the funding and establishment of the International Rice Research Institute (IRRI) in the Philippines where similar breeding projects with rice began in 1962.[6] So far as alleviating hunger in the Third World is concerned, this development was much more relevant because many more of the Third World poor rely on rice than on wheat for subsistence. By 1965 high yielding rice varieties had been developed. Like the wheat varieties engineered in Mexico, they needed to be shorter than the traditional varieties (100cm as compared to 160–180cm) but were capable of producing up to five times the yield of traditional varieties. Such results led proponents of the IRRI project to speak of 'miracle rice'.

In 1966 Norman Borlaug, who received the 1970 Nobel peace prize for research into high yielding wheat varieties, conveyed his excitement and classical Rostovian vision of the Green Revolution in a memorandum to Pakistan's secretary of agriculture as follows:

> Six months ago . . .we made the more optimistic forecast that wheat production could be doubled in five years. We now repeat that forecast . . .West Pakistan now has all the advantages which Mexico has, and more. You have the same latitude, the same irrigation, the same progressive farmers, and many of the same crops. You have saved years of research by the importation of dwarf wheat seeds. . . . This is a revolution.[7]

Less than a decade later HYVs of rice and wheat accounted for a high proportion of agricultural land in India, Pakistan, Nepal, Malaysia, Mexico and the Philippines as well as being adopted on a smaller scale in parts of the Middle East and North Africa. Yet in 1987, over twenty years later, it was estimated that 50 per cent of the world's hungry people lived in just five countries, four of them in Asia where the Green Revolution has taken place.[8] Why is this? Is it because the HYVs have not delivered the expected increases in food production? Or is it because the benefits of the Green Revolution have not accrued to the poor and hungry?

By the mid 1970s the application of HYVs in Third World countries had become extremely controversial as critics began to document many limitations, if not failures, of the Green Revolution. These limitations included the failure of the HYVs to adapt to practical agricultural contexts and, therefore, to increase food production; the aggravation of inequality between farmers; the dislocation of social and labour relations in the agricultural sector; increases in unemployment amongst the labouring classes; and the creation of an unnecessarily expensive and energy intensive agricultural sector with undesirable economic and ecological effects for Third World countries. The following sections focus on these alleged complications associated with the new technology. This is a problematic task as many studies of the Green Revolution have reached conflicting conclusions. However, it is possible to use the debate to draw some basic conclusions.

4.2 Growth in food production

In 1974 Griffin published results comparing growth rates of food production in the pre-Green Revolution period of 1955–65 with those over the period 1965–75 (i.e. spanning before and after the Green Revolution). Using appropriate statistical procedures he found unambiguously that in none of the four regions Latin America, Africa, the Near East or the Far East had there been an acceleration in overall food production. We shall not be concerned with the statistical tests here but table 4.1 shows the raw production figures which give a reasonable indication of the final results. If the Green Revolution had caused a substantial increase in wheat and rice production then, as Griffin argued, one would expect the figures for 1955–70 to be significantly larger than those for 1955–65. With the exceptions of wheat production in the Near and Far East and rice production in Africa, even the raw data in table 4.1 suggest that this is not the case. After statistical analysis Griffin concluded that there certainly had been a dramatic increase in the growth of wheat production in the Far East but that the situation regarding the Near East was unclear. He acknowledged that rice production had accelerated in Africa during the Green Revolution period but this made up less than 10 per cent of the total cereal production in Africa and so was of very limited significance. Griffin concluded:

> . . . despite the development of high yielding varieties of rice there has been no increase in the trend of production in the Third World as a whole.[9]

Table 4.1 Rate of Growth of Food Production 1955–1970

Region	Percentage annual rate of growth		
	All food	Wheat	Rice
Latin America			
1955–65	3.02	2.21	6.30
1955–70	3.05	1.28	4.85
Africa			
1955–65	2.49	2.25	2.50
1955–70	2.15	2.19	3.40
Near East			
1955–65	3.10	1.93	5.94
1955–70	2.89	2.23	5.49
Far East			
1955–65	2.94	3.48	3.30
1955–70	2.80	5.06	2.84

Source: Griffin, K. 1974 *The Political Economy of Agrarian Change*, pp 6, 7 and 9. London: Macmillan.

However, a breakdown of these four broad regions into smaller areas has shown that HYVs have been extremely successful in some areas. For example, in 1970 Falcon reported that there had been 'extraordinary growth of production in certain areas such as the Pakistan and Indian Punjab' but he noted that this had 'caused a loss of perspective on the total Asian picture'.[10] In fact he argued that dramatic increased productivity was rather sparse.

Two main reasons have been cited to explain the early lack of success of the Green Revolution. First, that the new varieties required exceptionally favourable moisture conditions as well as the precise application of complementary inputs such as fertilizers and pesticides, yet all these conditions combined were frequently not forthcoming in the 'real world' of Third World agriculture. And secondly, that traditional grains had tended to be tall on the stalk by natural selection not only to reach sunlight above surrounding weeds but also to withstand flooding whereas the shorter new varieties were often destroyed by floods.

In general, supporters of the Green Revolution no longer attempt to make miraculous claims about the new varieties solving world hunger. It is agreed that many of the varieties have had problems in the environments of the Third World although it is still claimed that the success of the wheat HYVs has been remarkable and, as Ladejinsky has commented, this is no mean feat.[11] Moreover, where increased yields due to the Green Revolution were obtained early on there seems to have been a consolidation of success. For example, in 1983 Gill reported great achievements in the growth of rice and wheat yields in the Punjab which he considered to have improved the quality of life in the region.[12] However, it is worth noting that the Punjab has a history of land reform as well as unusually well developed cooperative irrigation and credit systems. These factors are likely to have made the Punjab more amenable to coping with technological change.

Similarly, in Madras in India intricate crop rotations and fallowing systems designed to conserve and replenish the soil, elaborate methods of moving and distributing water, and the historical experience of three generations of new groundnut seeds introduced between the 1890s and the 1930s, made the region particularly receptive to the wheat and rice varieties of the late 1960s. By contrast, the old rice growing areas of the lower Gangetic plain in India produced stagnant yields because of soil exhaustion and degradation.[13] Thus there would appear to be some consensus that the Green Revolution has created *uneven* development though the extent of this development seems to have varied. This is what Griffin has called 'big gains in small areas'. Recent data indicate that these gains have been so large that, taking the average over the whole of Asia excluding China and Japan, yields for wheat, rice, corn and millets have increased modestly between the 1950s and the 1970s (table 4.2).

Table 4.2 Average crop yields in Asia, excluding China and Japan (tonnes per hectare)

Cereal	1950–59	1960–69	1970–79	% increase
Wheat	0.83	0.94	1.28	54
Rice	1.39	1.66	1.99	43
Corn	0.92	1.12	1.28	39
Millets	0.44	0.48	0.57	30

Sources: FAO 1981 The State of Food and Agriculture 1980, p17. Rome: FAO. Grigg, D. 1985 *The World Food Problem 1950–1980*, p224. Oxford: Basil Blackwell.

The reasons for this uneven development, however, have been hotly disputed. Lipton, in particular, has challenged the notion that the unimpressive performance of the HYVs in some areas was due to their need for more water and better irrigation than traditional varieties.[14] According to Lipton, the HYVs are frequently found on well irrigated areas not through technical necessity but because such areas are more prosperous and influential. On this basis he has claimed that the HYVs themselves are a positive technology for the poor producer, even if he or she is living on the less fertile land, because they provide him or her with higher yields for personal or family consumption. This point has not been fully resolved but there does seem to be a growing consensus that if the poor do utilise the HYVs then their requirements for water and irrigation do not create any significant impediment that would not also present itself with usage of traditional varieties. In the Philippines in 1975 seventy-eight per cent of irrigated rice was sown with HYVs but so too was as much as 50 per cent of the rainfed rice.[15] Nevertheless, even if we assume that Lipton is correct on this point, it is still necessary to consider many more implications of the new technology before we can conclude that it is a desirable innovation for the Third World poor.

4.3 The 'Matthew Effect' – polarisation of inequality

A major study of the social impact of the Green Revolution on Third World

farmers and cultivators became available in 1980. It was sponsored by the United Nations Research Institute for Social Development (UNRISD) and the research, which was published as the book *Seeds of Plenty, Seeds of Want* by Andrew Pearse, was carried out between 1970 and 1974. The study is given particular importance here not only because it is a very substantial piece of research but also because it proposed a major paradigm, albeit controversial, which has framed much of the debate about technological change in Third World agriculture.

Pearse identified two crucial and interrelated concepts relating to the Green Revolution: the notion that the HYVs represented only part of a whole *package of new technology* which needed to be applied in unison for the HYVs to perform satisfactorily; and the notion that in an unequal competitive market economy a *polarisation* of economic success was created by the Green Revolution between those wealthy enough to benefit from the new technology and the poor who could not.

Basically Pearse argued that in order to adopt the HYVs with a good chance of achieving high yields farmers had to be in a position to carry out stipulated weeding, watering, fertilizing, transplanting, plant spacing and periodic application of pesticides according to the severity of the pest attacks. In other words the 'technological package' could not be adopted partially with success – a characteristic often referred to as *indivisibility*. This made more demands on farmers than most traditional varieties which were adapted to give reasonable yields under poor or uncertain ecological conditions rather than to give high yields under optimal conditions. Thus, in order to adopt the HYVs local cultivators had to purchase fertilizers, chemical products, machinery, fuel and machine maintenance from the industrial sector, whilst the seeds themselves had to be obtained through urban distributors of large-scale farmers often from outside the locality. According to Pearse, this increased dependence of the locality on the urban-industrial network, biased the advantages of HYV adoption in favour of those with the experience and social skills necessary to cope with the city, the bureaucracy, and political interest groups. By contrast, it handicapped those with traditional knowledge of the local idiosyncracies of soil and climate and whose time was expended on the labours of husbandry rather than in manipulating the rural-urban nexus.

Pearse contended that in rural market economies (whether capitalist or pre-capitalist) land propriety forms the basis of control over the resources and prestige. As a result it is the farmers with the larger landholdings who are best placed to involve themselves in the enterprise of rural-urban commercial relations and concomitant technological innovations. By contrast, the poor cultivators with relatively little fertile land find themselves unable to compete successfully with their wealthier counterparts and may be additionally thwarted in doing so because they have become dependent on richer farmers through debts or tenancy arrangements. Pearse concluded:

> Our studies revealed that small cultivators lacked the time, influence, literacy, and social affinities possessed by the large proprietors that made it possible for the latter to be in touch with government programmes and facilities and receptive to technical information. Thus, peasants may find themselves competitors for credit or irrigation facilities with agriculturalists who have city houses and political connections; poor villagers may have to compete for institutional credit with the local elite who make up the village committees that allocate the credit; illiterate, ill-clad cultivators may have to argue their case in town offices with status-conscious officials.[16]

Poor farmers, then, did not risk their limited resources by investing in the technological package. Moreover, and very significantly, Pearse found that the increased commercialisation of production and exchange created by the Green Revolution served to undermine the self-provisioning agricultural system of small cultivators in two important ways. First, the expectation of increased net returns from the HYVs increased the price of land in such a way as to prevent the expansion of the small cultivator. And secondly, as the modern monetised economy encroached further into the countryside, village crafts which provided smallholders with supplementary income were replaced by manufactured goods over which they had no control. This evidence led Pearse to argue that in competitive market societies where significant inequalities in land ownership have been established, the introduction of the Green Revolution technological package generated polarisation between the rich and poor farmers in the form of the 'Matthew effect' as follows:

> For unto everyone that hath shall be given and he shall have abundance: but from him that hath not shall be taken away even that which he hath.
> (Matthew, Ch. 25, v. 29 cited by Pearse 1980, p5)

Hence, according to Pearse, in an unequal society the HYVs were not a neutral technology because the inputs they required specifically advantaged the richer sections of the society and disadvantaged the poorest such that their vulnerability to hunger and undernutrition was increased.

Many comentators have reported findings which support Pearse's basic thesis. For example, in the Punjab, where adoption of the new seeds and techniques was particularly profitable and widespread amongst small as well as large farmers due to very favourable water control, Junankar found that the inequalities of land owned, land available for cultivation, and land actually cultivated had all increased due to the Green Revolution. The category of farmers with greatest growth up the agricultural ladder was that of medium-sized (10–20 hectares owned) whilst amongst the small farmers more moved down the ladder than up it. Janunkar concluded from this that not only had inequality increased between small and large farmers but that it had also increased between the medium-sized and small farmers.[17] One additional reason why the varieties may not have been neutral, which has not yet been mentioned, relates to the choices of varieties as a basis for local food consumption. The essential point revealed by researchers is that those HYVs whose palatability is not preferred to traditional varieties are unlikely to be adopted by the poorer farmers who grow crops for their own

consumption unlike the larger farmers who frequently serve a regional or even international market.[18]

Of course, as Bayliss-Smith has noted, the process of *differentiation* in which the rich farmers got richer and the poor poorer predated the Green Revolution in parts of India as doubtless elsewhere. However, he has also pointed to the fact that between 1955 and 1970 in one Indian village studied in depth the 'Untouchables', a poor but not the poorest caste (i.e. class), saw their real incomes decline by about one third.[19] In another Indian village Chambers and Farmer summarised the social impact of the Green Revolution as follows:

> . . .the very small cultivators and the agricultural labourers are trapped. If a new technology . . . . displaces them they have no chance of becoming small cultivators elsewhere. . . . . The prospect for many of the landless scarcely bears contemplation. Extruded from the bottom of the pile, forced in desperation to leave their villages, they will swell the numbers of urban migrants and of rural transients whose lot will be more terrible for being so often unseen and so easy to avoid seeing.[20]

Moreover, after reviewing much of the literature on the impact of the Green Revolution on South Asia, Bayliss-Smith concluded:

> . . . technological change alone is quite unable to reverse the existing social tendencies towards polarisation of rich and poor – indeed, it accelerates these tendencies.[21]

Clearly Pearse and many other critics of the Green Revolution have marshalled much evidence that the new technology not only resulted in uneven developement amongst regions but also unequal development between classes of farmers within regions. Figure 4.1 illustrates Pearse's 'Matthew Effect'. The large and medium-sized farmers seem to have been successfully modernised, having achieved a Rostovian 'take-off' with the Green Revolution. Meanwhile the small cultivators have become increasingly marginalised; perhaps having to sell off some of their land to avoid hunger in the short term.

On the other hand, both the technological package and polarisation aspects of Pearse's model of the Green Revolution have been strongly challenged. One of the most direct challenges has come from Lipton who maintains that the HYVs can out-perform local varieties in most soils *without* extra fertilizer and are, therefore, *technologically* beneficial to the poor farmer producing food for his or her own consumption. Lipton dismisses the notion of the 'technological package' as a myth because he believes poor farmers can benefit from only partial use of inputs.[22] A similar point has been made by Baker with respect to the Indian experience of the Green Revolution. He claims that the practice of partial adoption of the technology is well developed in India:

> In effect the Green Revolution is probably only less divisible than a packet of cigarettes, and already there is a great deal of the 'one cigarette, one match' style of trading in Green Revolution inputs.[23]

The 'Mathew Effect': Pearse and Junankar Model

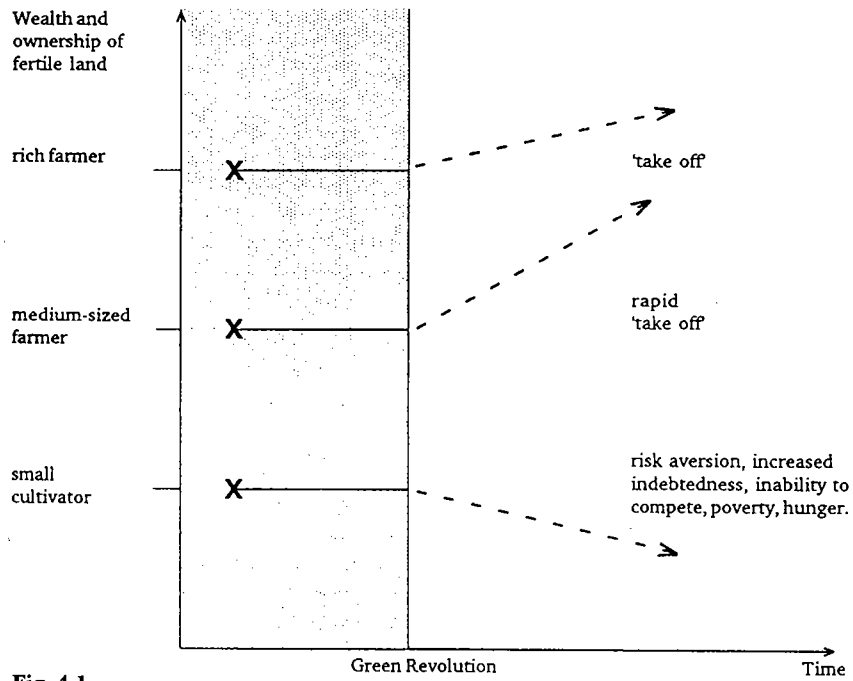


Fig. 4.1

The claim that the HYVs have increased inequalities between small and large farmers has also been disputed in studies which, almost without exception, were carried out subsequent to Pearse's research. For example, Hayami cited a 1978 IRRI survey of thirty-six villages throughout Asia which found that in only one was there a significant lag of small farmers behind large ones in the adoption of HYVs.[24] It should be noted, however, that this survey considered only *irrigated* farms. Such irrigated land is owned by the wealthier farmers even though some of them own only small plots. Small farmers *per se* are not poor though they usually are. Consequently, this study seems to have bypassed serious consideration of the plight of the *poor* cultivator.[25]

In 1983 Prahladachar undertook an extensive, though not complete, review of the literature on the income distribution effects of the Green Revolution in India. He concluded that the Green Revolution had not been a 'large farmer phenomenon' and rejected the claim that the economic gains from the HYVs had gone disproportionately to large farmers. In his view studies in which small farmers were found to have lost out can be explained either by the non-neutrality of the economic, social and political institutions

impinging on the farmers and technology or by the fact that the studies contain methodological deficiencies such as not testing their quantitative claims statistically or not controlling for soil quality, irrigation and levels of inputs across farms.[26] In the same year two further studies by Blyn and Leaf reported that in the Punjab not only had large and small farmers gained from the Green Revolution but it had even *reduced* income inequality between farmers.[27]

Yet other studies have reached intermediate conclusions in which the new technology is exonerated but differential adoption rates are attributed to the small farmers' greater difficulty in paying the costs involved in acquiring information, efficient inputs and credit.[28] These intermediate conclusions contrast with Pearse's in two ways. Firstly, the problems of differential adoption are seen as surmountable within the basic Green Revolution development strategy (e.g. better marketing of the technology). And secondly, although large farmers are considered to benefit more than poor cultivators from the Green Revolution, the poor are *also* viewed as *beneficiaries* rather than victims of it.

4.4 Dislocation of social relations

Although the HYVs have not met with widespread success, where they have produced high yields, critics maintain that poverty-creating social relations have developed as a result. Bardhan and Bardhan argue that landowners in India who had previously leased out their land became enterprising capitalists committed to profit maximization once they realised how the new technologies could enhance the profitability of cultivation. With new found enthusiasm for agriculture, landowners in some cases evicted tenants so that the land could be farmed.[29] Indeed a study for the World Bank on the farm-size in the Indian Punjab reported that during the 1960s mechanised farms grew by more than double on average because landlords had decided to cultivate land they had previously rented out.[30] Other poverty-creating trends have been documented. For example, cash rents were found to have increased particularly after the introduction of the HYVs due to the decrease in land made available for rent, the increase in potential tenants and the substantial increase in the price and productivity of land.[31]

It has also been reported that landowners began to favour a fixed cash rent for land instead of the more traditional share-cropping because they no longer wished to manage sharecropping agreements when more lucrative farming possibilities were available.[32] By increasing rents landowners effectively passed on some of the costs of their factors of production (i.e. the new technologies) to their tenants. Under traditional landowner-tenant relationships this was less common especially since both were part of a community. However, there is some evidence that the intensification of capitalist agriculture encouraged by the Green Revolution has caused a dramatic increase in absentee ownership – as much as double in some cases –

and consequently an increase in more impersonal money based relationships.[33]

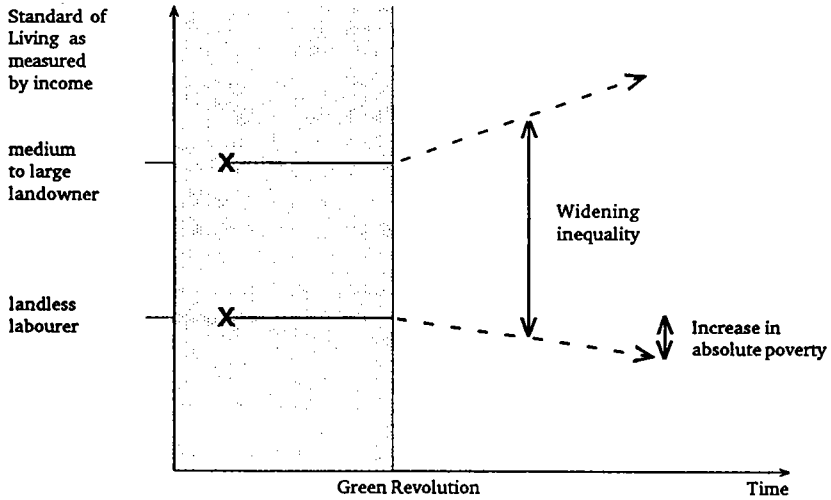
These trends are likely to have increased the vulnerability of the *landless* poor to undernutrition in the regions where the Green Revolution was implemented. Unlike the small farmers who can, within limits, *produce* their own food, landless labourers are solely consumers/workers who do not have the high yields from their own crops to offset inflationary rents and increased exploitation of their labour. On the other hand, supporters of the Green Revolution such as Prahladachar have argued that although landless labourers in India have become poorer *relative* to the richer farmers[34], they have also gained in *absolute* terms. Farmers might increase their income status by some 76 per cent but agricultural labourers were also found to increase theirs by some 30 per cent.[35] On this view the technology is considerd to have benefitted everyone. So there is agreement that the Green Revolution accentuated inequalities between big or medium-sized land-owners, on the one hand, and landless labourers, on the other. The point of contention is whether or not the situation of landless labourers deteriorated in absolute terms as a result of the Green Revolution (fig. 4.2).

This basic difference remains to be fully resolved but there are reasons for favouring the Bardhan model. Those studies which have claimed absolute gains for labourers tend to have confined themselves to analysis of wages and to the employment effects of the HYVs and inputs. The latter, which is taken up in more detail in the next section, is problematic because it does not take account of the possible major labour displacement (and resultant unemployment) caused by the mechanisation of farming often associated with the large-scale uptake of the HYVs. Moreover, studies which consider only wages and employment effects fail to take sufficient account of either labourers' rising costs of living (e.g. higher rents) or the increased exploitation imposed on labour in order to receive absolute rises in wages. This increased exploitation may take the form of a lower wage per hour worked or, more unconventionally, it may relate to the amplification of the gruelling nature of the work. To judge that landless labourers have gained from the Green Revolution because their wages have increased is surely too mechanistic. We should also ask whether or not the escalation of rents and other changes in capital-labour relations have outweighed such wage increases as have occurred. Tragically it seems that they have at least in some areas, with a subsequent increase in poverty and vulnerability to hunger.

4.5 Creation of unemployment

There is general agreement that certain aspects of the Green Revolution have been labour-creating and this is broadly considered desirable in most Third World countries where there are large numbers of unemployed and underemployed people. The greater intensity of cultivation required by tending to the HYVs with fertilizers and pesticides, together with the increased labour required for additional yields and harvests, made possible

The Bardhan Model: Green Revolution in India



Prahladachar Model: Green Revolution in India

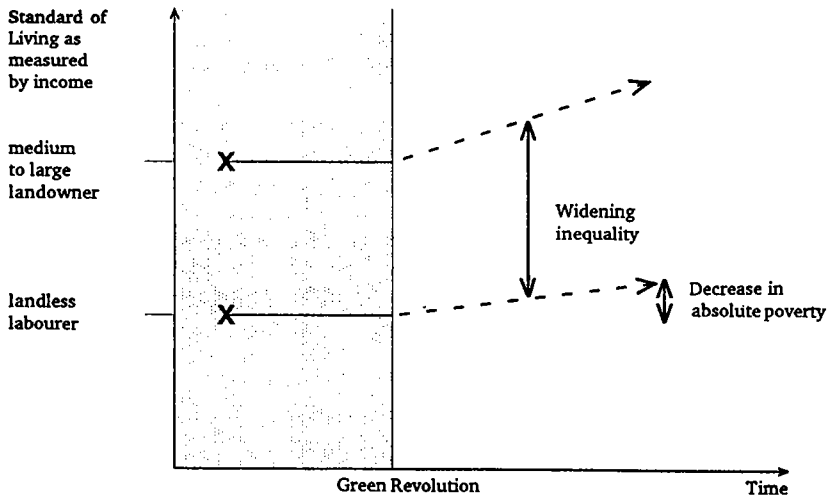


Fig. 4.2

by the faster maturing HYVs, have had the effect of increasing the demand for hired labour. Though in the case of pesticides it has been claimed that employment effects are not necessarily positive because they can displace manual labour in weed clearing activities, for example.[36] More significantly, critics argue that, because of the increase in land prices associated with the HYVs, farmers have sought to increase the size of their farms with a concomitant tendency to *mechanize* the production process by investing in tractors and combine harvesters. So, although the Green Revolution technologies themselves may be labour creating, it is frequently claimed that their introduction into an unequal competitive agricultural sector has encouraged technologies of mechanization which are sufficiently labour-displacing to outweigh the former employment creation.[37]

This line of argument has been challenged with some commentators emphasising that the adoption of tractors by large farmers began before the Green Revolution or that there is no evidence that the introduction of HYVs has accelerated tractor adoption.[38] In other cases it has been found that even where tractor mechanisation has taken place demand for labour, especially hired labour, has increased because the increased productivity has outweighed the labour saving aspects.[39] In this respect tractors may be more benign than combine harvesters. A study of two 'well-mechanised' districts of Rajasthan in India concluded that combine harvester, but not *tractor*, mechanisation combined with the introduction of HYVs was labour-displacing.[40]

Of course, the adoption of tractors in Third World countries may have other advantages and disadvantages. Arguably one advantage of mechanisation is that it displaces animal power and allows more planting to be given over to crops that people need instead of animal feed. One disadvantage is that it leads to increased dependence on Western transfer of technology because it is difficult for indigenous tractor firms to compete with the well tried Western machines.[41]

Profit maximization through efficient land use may not always be the only motivation for farmers to adopt mechanisation. For example in 1970 the World Bank proposed a $25 million loan to finance tractors in India and had several other similar loan proposals pending. Also in Pakistan a World Bank loan provided for the special importation of tractors and made available special credit arrangements.[42] Furthermore, as the richer farmers expand the size of their landholdings, supervision and management of labour may be perceived to be, and actually be, more difficult. Mechanisation can radically reduce such management problems with hired labour.[43] This is particularly true if agricultural labourers seek greater wages because of the higher yields resulting from their labour or if there exist laws concerning minimum wage requirements for labourers.[44] Thus capitalist farmers have been attracted to mechanisation in order to avoid labour disputes associated with high wage demands. Obversely, mechanisation can make the labouring classes more vulnerable to exploitation and unemployment because their labour and skills become more dispensable.

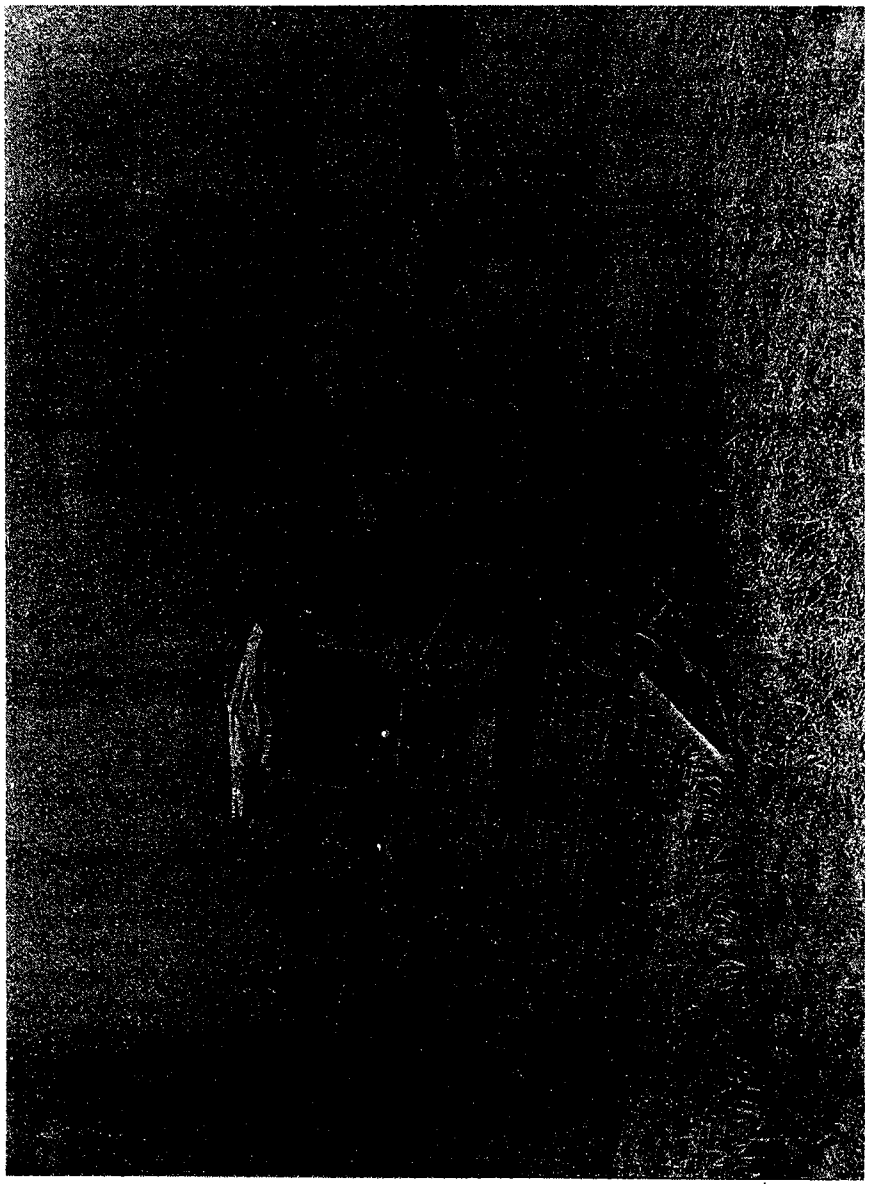


Plate 4.1 Harvester-threshers at work in a grain field in Turkey
Source: FAO. Photo by H. Rabben.

There is also some evidence of secondary negative employment effects of the Green Revolution. For example, in Bangladesh many women were employed in labour intensive rice processing techniques by hiring themselves out to richer families in exchange for food. The processing was usually carried out in family compounds. However, the introduction of HYVs put a strain on this relationship because the new varieties were more difficult to process by the traditional techniques and the higher yields took up more space in the compounds so that extra labour had to be fed. For these reasons employers now have added incentives to send their rice to mills where the processing is mechanised with consequent unemployment for many women.[45] This kind of unemployment can be particularly damaging for women because the commercialised agriculture (credit systems etc.) associated with the Green Revolution tends to be aimed more at men than women due to the traditional position of women within the family. Unemployment, therefore, can lead to women's control over the family resources being substantially diminished.[46]

4.6 The Environmental Cost

As already noted, Green Revolution technologies were exported to Third World countries from the West and mainly the US. Not surprisingly, therefore, they shared many of the characteristics of the technology of the US food production system. In particular, they depended on large energy inputs. The most important energy resource for Westernized agricultural systems, and hence the Green Revolution, was and still is fossil fuel, which is required for machinery, transportation, fertilizers and pesticides. The dominance of the industrialised countries in the world consumption of manufactured fertilizers is evident from table 4.3.

Table 4.3 Percentage distribution of consumption of manufactured plant nutrients in 1974/75.

	Region				
Fertilizer	North America	Western Europe	USSR and East Eur.	Non-Comm. Asia	Comm. Asia
Nitrogen	24	18	26	10	11
Phosphates	24	25	23	7	5
Potash	25	25	33	4	1

Key: Comm. = Ruled by Communist Party

Source: Allen, G.R. 1977 'The World Fertilizer Situation' *World Development* vol.5, p526.

This dominance has continued not just with respect to fertilizers but also pesticides. In 1978/79 the industrialised countries used approximately 75 per cent of the world's consumption of fertilizers and the US alone consumed over one third of all pesticides used.[47]

4.6.1 Fertilizers

The Green Revolution enticed many Third World countries to import much

more chemically based fertilizers than they had done previously. But due to the 'energy crisis' of the early 1970s fertilizer consumption began to outstrip its production.[48] Some commentators then noted that as these energy shortages occurred, with consequent price increases, the success of the Green Revolution could be affected in a negative way. In 1973 Pimentel and others concluded that the USA was using an equivalent of 80 gallons of gasoline to produce one acre of corn and they doubted that many Third World countries could afford the high costs this entailed given increases in energy shortages.[49] Just one year later Steinhart and others, addressing the very same issue, painted a much bleaker picture.

> It is quite clear that the US food system cannot be exported intact at present. For example, India has a population of 550×10^6 persons. To feed the people of India at the U.S. level of about 3000 calories per day (instead of their present 2000) would require more energy than India now uses for all purposes. To feed the entire world with a U.S. type food system, almost 80 per cent of the world's annual energy expenditure would be required just for the food system.[50]

These authors warned against following a high-tech agricultural policy which could be too expensive for poorer countries and advocated an increase in the worldwide use of natural manures as substitutes for artificial fertilizers. Yet five years later the terms of trade for Third World countries had continued to deteriorate and the FAO reported that the poorest countries 'were hit by sharply rising costs of fertilizers'.[51] India, for example, had increased its fertilizer use by a factor of seven during the thirteen year Green Revolution period (1966/7 – 1979/80) compared to the thirteen year period 1952/3 – 1965/6.[52] As a result of the Green Revolution in India's Punjab fertilizer consumption rose from 0.76 million tons in 1966 to 2.38 million tons in 1972.[53] Warnings such as those above came too late for Turkey in 1969 which sought to buy artificial fertilizer for its extensive HYVs of wheat but could not afford the price.[54] In fact, the use of fertilizers grew more than twice as fast in the Third World as in industrialised countries between 1969/70 and 1978/79 and this trend has continued into the 1980s.[55] Fig. 4.3 shows that the greatest intensity of chemical fertilizer use in the the Third World (excluding China) in 1985 was in Central America and South and South-east Asia, where the Green Revolution was initiated, and the oil-rich Middle-east. Notably, fertilizer usage is least in Africa where the Green Revolution approach to agriculture still faces major *technical* problems. In 1988 the prices of fertilizers (especially nitrogenous-based) were still rising – as high as 33 per cent in some cases.[56]

The research of some commentators implies that this situation is as crazy as it is expensive. For example, in 1985 Diwan and Kallianpur, some twenty years after the beginning of the Green Revolution, found that in India fertilizers have had some positive effects on increasing wheat, but not rice, production. Their overall assessment was that the contribution of fertilizers to foodgrain production in India has been quite low and they concluded that:

> the emphasis placed by the governments and international agencies on increased use of fertilizers everywhere may be misplaced.[57]

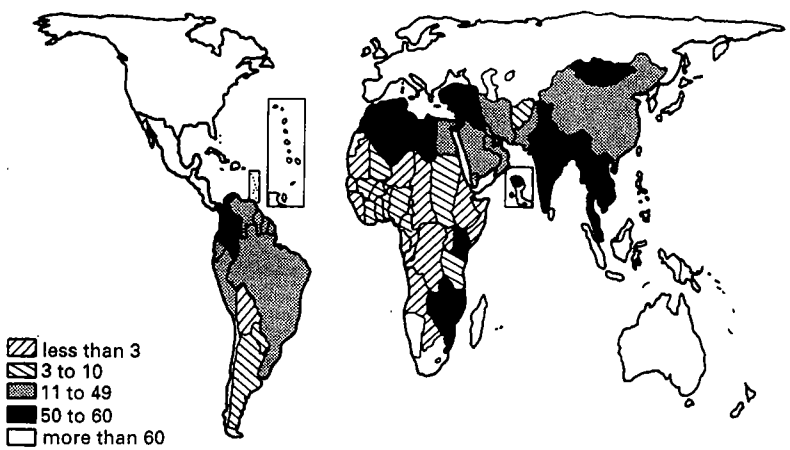


Fig. 4.3 Fertilizer use in less developed countries.
Source: FAO 1985 *World Food Report 1985*, p68. Rome: FAO

This seems to be supported by Bayliss-Smith who reviewed twenty-two rice-growing systems and concluded that many traditional methods of cultivating rice can not only be more energy efficient than high-tech inputs (i.e fertilizers and pesticides) but can also increase yields as much as, if not more than, the Green Revolution.[58]

Critics of the Green Revolution also argue that fertilizers are not only costly, but they often have to be provided by Western-dominated transnational companies whose interests do not coincide with those of local farmers. This might be dangerous because increased dependence on fertilizers is likely to result in increased dependence on the West and an even greater reduction in the autonomous political and economic power of Third World countries.[59] Furthermore, it means promoting high-tech agriculture, which has worked due to heavy investments in the West, in Third World nations without first assessing the system it is to replace.[60] This has been most obvious in Africa where initial lack of attention to local environmental and economic conditions led to a basic failure to develop even moderately workable HYVs.[61]

In addition to the problems that high usage of chemical fertilizers presents for the economic development of Third World countries are long-term consequences for the environment. These should not be abstracted from the question of development because environmental destruction can undermine the sustainability of people's health and livelihood. Experience in the West suggests that serious problems of environmental pollution can result from heavy usage of chemical fertilizers. One of the most significant

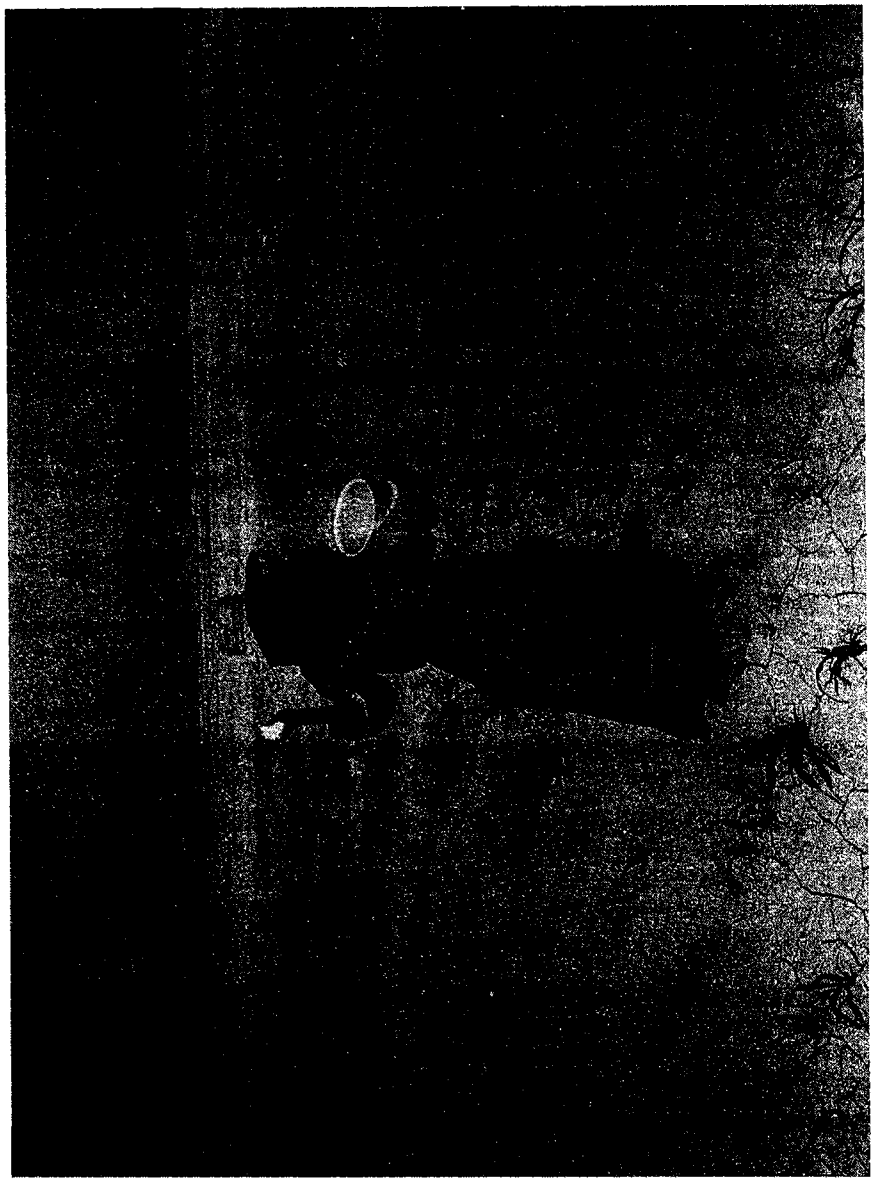


Plate 4.2 Woman fertilizing a field
Source: FAO. Photo by J. Van Acker

environmental hazards associated with fertilizers is the presence of nitrates in drinking water.

Nitrates come mainly from fertilizers, animal manure and mineralisation of organic matter. Once excess nitrate is present in the soil it may percolate through the various soil strata, along with water, eventually passing beyond the reach of plant roots and into ground water aquifers. This process is known as *leaching*. Nitrates themselves are not considered particularly toxic but when ingested they can be readily reduced to nitrites due to microbial action in the mouth and/or stomach. High nitrite levels can be dangerous to babies whose haemoglobin is particularly susceptible to oxidation causing a fatal condition known as methaemoglobinaemia. This is also called "blue baby syndrome" because it is associated with a lack of oxygen in the blood which causes a blue discolouration of the skin.[62] Also, in the acidic juices of the stomach, nitrites can combine with amines to form nitrosamines which are amongst the most carcinogenic (cancer inducing) environmental compounds. They have been shown to have a carcinogenic effect in 39 animal species including primates and, although *human* epidemiological studies of their carcinogenicity have been inconclusive, high levels of nitrosamines derived from drinking water should be considered a major health risk.

Perhaps the best known effect of fertilizer run-off is *eutrophication* – the excessive dosing of lakes, irrigation reservoirs and canals with nitrogen and phosphate – culminating in population explosions of algal plants beyond the capacity of the ecosystem. This results in the death of nearly all the animal and plant life in the water body and increases the burden on limited water supplies. Despite these environmental problems global fertilizer consumption per caput climbed from approximately 5 kg in 1950 to 25 kg in 1983.[63]

From an ecological point of view there are alternatives to the extensive use of chemically manufactured fertilizers. One strategy is to use organic crop residues as sources of soil nutrients in the form of *mulch*. Residues such as stalks and leaves can contain between 40 and 90 per cent of the nutrients that crops remove from the soil.[64] Mulch also acts as an important soil conditioner in many parts of the world, especially in the tropics, by reducing soil temperature, increasing the amount of rainwater that filters into the soil and raising the water-holding and erosion-resistant capacity of the soil. According to Harrison, addition of mulch in the semi-arid zones of Niger has been found to increase the yield of millet grown without chemical fertilizer four-fold and to double the yield of artificially fertilized plots.[65]

Organic fertilization can also be achieved by using cattle, chicken or pig manure in the form of *slurry* which is an excellent soil conditioner. In 1987 it was estimated that an additional 10 to 15 million tons of nitrogen and 5 million tons of potassium and potash each could be obtained in the Third World if half the available human and animal manure were used.[66] Intercropping (i.e. growing two or more crops intermingled in the same plot) is yet another method of enhancing the fertility of the soil especially if crops of different heights, maturity periods and root depths are combined because the plants then 'compete' less for nutrients, sunlight and water. The

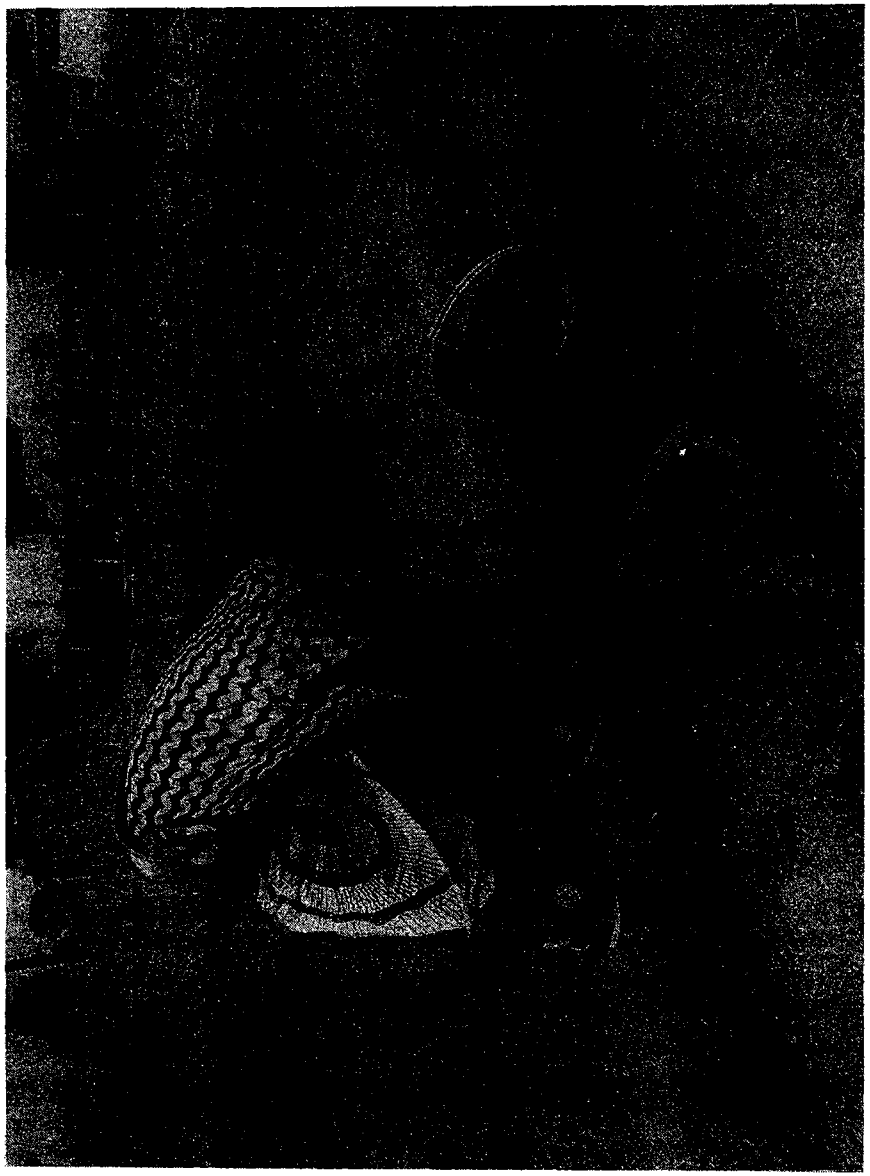


Plate 4.3 A farmer applying organic fertilizer to her vegetable plot
Source: FAO. Photo by A. Wolstad

main advantage of monocropping (i.e. growing the same crop all together in the same plot) is that of mass fertilizer and pesticide application. However, there is some evidence to suggest that in Africa intercropping is superior to monocropping.[67]

Though these ecological arguments are resisted by some farmers and transnational chemical companies[68], they are accepted by the United Nations Food and Agriculture Organisation (FAO). Despite this, in 1989, the FAO argued against more organic (i.e. low-input) farming systems as follows:

> It is now commonly argued that monocrop systems based on off-farm inputs cannot be sustained and that there should be a shift to low external input mixed farming systems which would be more appropriate for resource-poor farmers. While this is a laudable objective from both an ecological and an equity point of view, it is unrealistic for many situations at the present time from both economic and humanitarian standpoints because food availability would decline and food prices would rise.[69]

The FAO argument emphasises the important point that ecological issues cannot and should not be discussed in isolation from political and economic ones. However, its representation of future difficulties is somewhat misleading by using the word 'unrealistic' to refer to a *lack of political will.* If sufficient resources were made available and appropriate government policies were implemented then it seems extremely unlikely that food prices would have to rise in order to reduce the dependence of Third World countries on chemically based fertilizers.

4.6.2 Pesticides

There is no doubt that pests destroy a significant proportion of the world's food production. The FAO has estimated that 35 per cent of wheat production and 40 per cent of potato production is lost to pests and diseases. Moreover, about 10,000 of 100,000 known species of insects have been identified as pests and reckoned to consume about 30 per cent of global food production.[70] Chemical pesticides (i.e. fungicides, herbicides and insecticides) have had a positive effect in reducing the prevalence of pests, perhaps most notably in the locust control programmes of the Sahel. Where pesticides have been effective they have not only reduced losses in food production but also contributed to the suppression of typhus and malaria epidemics. However, pesticides can also have damaging effects on the agro-ecosystem and these have been magnified by the more extensive use of pesticides encouraged by the Green Revolution. This is not only because the HYVs proved to be more susceptible to pests but also because of the knock-on effect of the Green Revolution as a general 'moderniser' of agriculture in parts of the Third World. Consequently, the Green Revolution created many new export markets for the agrichemicals industry which manufactures pesticides.

Many countries grow crops primarily for export in order to gain foreign exchange rather than for domestic consumption. Such crops are known as

cash crops and can be contrasted with wheat and rice HYVs which are usually grown as food crops for domestic consumption. Up to 70 per cent of the pesticides used in the Third World are used for cash crops and so clearly not all the adverse environmental effects of pesticides can be directly attributed to the Green Revolution. This is particularly true because the most severe health and environmental problems associated with pesticides are thought to result from aerial spraying which is most common on cash crop plantations.[71] Nevertheless, a significant proportion of their use is associated with the rice and wheat HYVs. According to Professor Conway of London's Imperial College, 'the introduction of the new high yielding varieties (HYVs) has brought about dramatic changes in rice cultivation, the structure of the rice agro-ecosystem and in particular the composition of the pest, disease and weed complexes'.[72] In the Philippines, home of IRRI, pesticide imports grew fourfold between 1972 and 1978[73] and the FAO has estimated that by the year 2000, sixty-seven per cent of the seeds used in the Third World will be of the HYV-type which are generally more vulnerable to pests.[74] Furthermore, the relatively large amounts of fertilizers required for HYVs can produce luxuriant growth which supports a greater pest population.

The sale of pesticides to the Third World is big business for the agrichemicals industry. It is a business frequently facilitated by loans organised by national banks in collaboration with the World Bank and other bodies such as the United States Agency for International Development (USAID) or the Overseas Private Investment Corporation (OPIC). Credit officers from the national banks offer loans to farmers to enable them to buy pesticides but critics of this process point to a neglect of safety and environmental issues. For example, in 1981 Weir and Shapiro reported that not only did the World Bank staff not include a single pest control expert to advise on pesticide use in its agricultural projects but the organisation frequently did not even specify which pesticides could or could not be used in a project.[75] Yet some of these pesticides are extremely toxic substances.

Use of pesticides such as DDT, Aldrin/Dieldrin, 2–4–5 T and paraquat have been banned or severely restricted in many Western countries because of their environmental hazards, but they have continued to be exported to the Third World. In the West use of many pesticides is only considered safe if special protective clothing is worn yet in many Third World countries such protective clothing may not be available, affordable or even bearable due to the heat. In 1982 Bull reported that in Central America most workers exposed to pesticides had no protective clothing. He also found that 60 per cent of the workers' houses had no toilet and 75 per cent no running water despite the fact that these are essential to avoid further exposure by having to wash in the pesticide-contaminated irrigation channels.[76] As recently as May 1990 it was reported that plantation workers themselves were sprayed directly with the pesticides to prevent them from transporting pests from one field to another.[77]

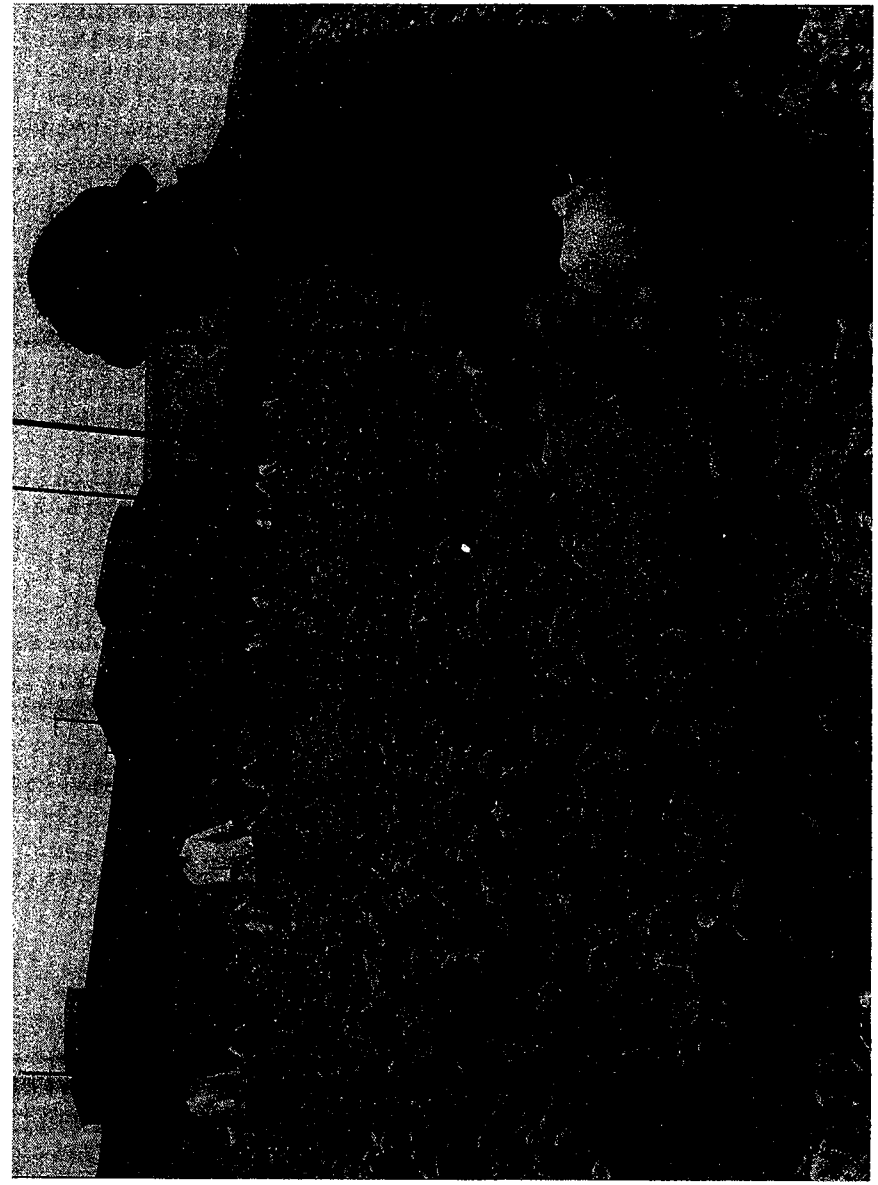


Plate 4.4 A cabbage field being sprayed with insecticide in Shangai
Source: FAO. Photo by F. Mattioli

Estimates of the most serious adverse health effects of pesticides vary widely. In 1976 a World Health Organisation (WHO) report on occupational health concluded that 'in some countries field surveys of poisoning among spraymen [and women ?] exposed to agricultural chemicals revealed an average prevalence of up to 40 per cent of workers with symptoms of poisoning during a spraying period'.[78] Two years later Agarwal claimed that 500,000 people throughout the world were either killed or incapacitated by insecticide poisoning every year.[79] In 1982 the Pesticides Action Network (PAN) estimated that each year at least 375,000 people in the Third World were poisoned and 10,000 killed by pesticides.[80] More recently, in 1987 Peng estimated an annual figure of 40,000 deaths due to pesticide poisoning.[81]

Though Third World countries use less than one third of the world's pesticides they suffer three-quarters of the pesticide fatalities. There are two main reasons for this. Firstly, and already mentioned, the difficulty of actually applying the recommended safety standards in some Third World countries. This can result in the misuse of pesticides in some cases because the safety directions are actually incomprehensible to the users. And secondly, many pesticides which are banned in the West are exported by the agrichemicals industry to the Third World where there are generally less stringent regulatory controls on toxicity screening. In 1979 a quarter of the pesticides exported to the Third World by the US were either banned or unregistered in the US and in 1984 it was reported that some 41 countries in the Third World had no formal controls on pesticide usage.[82] Even those countries with regulatory controls cannot always guarantee that the regulations are enforced. For instance in 1983 it was reported that 6 major agrichemicals companies were refusing to cooperate with Brazilian government officials seeking toxicity data on the companies' pesticides.[83]

In order to tackle some of these problems the FAO drew up and adopted on 22nd November 1985 the *International Code of Conduct on the Distribution and Use of Pesticides*. This code recommended that the control of pesticide usage should take full account of local needs, social and economic conditions, levels of literacy, climatic conditions and availability of pesticide application equipment'.[84] Amongst many other things, it also recommended that the pesticide manufacturing industry should 'submit the results of all [safety] tests to the local authority responsible for independent evaluation and approval before the products enter the trade channels in that country'.[85]

Unfortunately this cannot counteract some of the environmental damage which has already occurred. For example, in South India extensive use of pesticides has caused contamination of paddy fields where the local villagers depended on paddy-field crabs for food.[86] The poisoning effects of pesticides (especially chlorinated hydrocarbons) on fish in Asian paddy fields also threaten the nutrition of many of the rural poor who depend on fish as a major source of protein, in some cases for religious reasons the only source of protein. Green Revolution-based monocropping of rice in Southeast Asia, with its high pesticide inputs and low water levels to accommodate the shorter HYVs, has made paddy-field fish farming less productive and poisoned the fish and waters. Water buffalo have also been put at risk from contaminated water.[87]

Compounding these problems are two major ecological difficulties associated with the use of pesticides. The first is that the pesticide may kill predators of the target pest more effectively than it kills the pest, or it may kill the predators of a species which has the potential to be a pest once its natural enemies are destroyed. As a consequence, the population of the target pest can increase rather than decrease. The second involves the ability of pests to evolve resistance to pesticides. In the case of insecticides the speed with which the pest can develop resistance depends on its genetic and behavioural characteristics. These may allow it to reduce the amount of poison into its body or somehow detoxify the chemical while in its body. As these resistant insects reproduce they pass on resistant characteristics to their offspring until a large proportion of the pest population is of the resistant type. The problem of resistance is important because it often leads to even heavier applications of pesticides. Bull explains the problem as follows:

> The initial response to resistance usually consists in increasing the dose, with all the attendant environmental effects that this brings, including the increased threat to the health of farm labourers. In addition, the farmers' costs increase, especially when new pesticides are introduced in place of the old. . . . . The continuous rush to invent new chemicals faster than the insects can develop resistance, even if it were possible, would be a very expensive and difficult solution.[88]

During the first ten years of the Green Revolution in Southeast Asia the number of rice pests resistant to at least one insecticide grew from eight to fourteen.[89] Conway has argued that the rice pest resistance problem now being experienced in Southest Asia, especially with the brown planthopper, is due to the the introduction of the HYVs which can be grown throughout the year requiring up to ten or twenty times the previous annual rate of pesticide application.[90] Such increases in pesticide usage are certainly problematic if Bosch is correct in describing much of insect control as 'a shambles'.[91] According to the FAO, the number of pesticide-resistant insect species doubled in the twelve years from one hundred and eighty-two in 1965 to three hundred and sixty-four in 1977, a period coinciding with the introduction of the HYVs in many parts of the Third World.[92]

4.6.3 Genetic Resources

Over thousands of years subsistence farmers, especially in the South, developed a large range of crop variability through seed selection techniques. They did this because no single wheat or rice variety provides adequate protection against blights, monsoon failures or pests. New genetic material is required to breed for crop resistance against disease and continually mutating pests. Thus, the preservation of plant genetic diversity

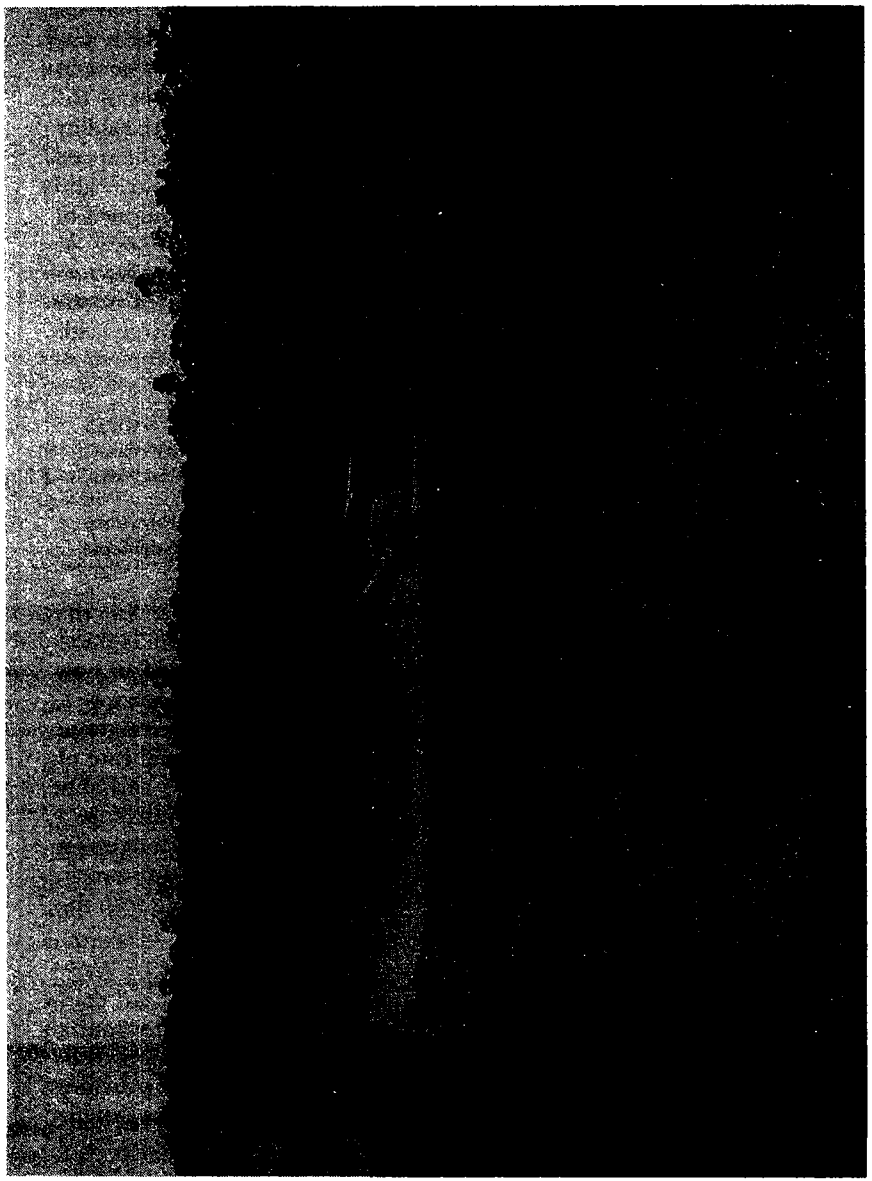


Plate 4.5 A helicopter spraying a plantation with an oil-based fungicide in Kerala State, India
Source: FAO. Photo by Shell International Petroleum Company Ltd

is important to subsistence agriculture. This is especially the case in the Third World, but historically perhaps the most striking example of neglecting genetic diversity was the Irish Potato Blight. In the sixteenth century English explorers returned from the Caribbean with only one variety of potato. The genetically uniform crop was planted throughout Europe and when potato blight struck in Ireland massive damage was done to subsistence agriculture, helping to create conditions for a devastating famine.[93]

What has this got to do with the Green Revolution? Loss of genetic diversity is often referred to as 'genetic erosion'. There are several candidate causes for genetic erosion and many commentators believe that the promotion of HYVs and their associated uniformity has been one such cause. The Green Revolution can be implicated in genetic erosion either directly or indirectly. For example, Wilkes notes that in India where many people depend on legumes there are twice as many acres of wheat planted as chickpeas whereas before the Green Revolution the acreage devoted to each was approximately equal.[94]

The Green Revolution can be implicated indirectly because it has attracted the involvement of large agrichemical companies which have been able to provide, and profit from, the fertilizer and pesticide inputs required by the HYVs. In so doing, the Green Revolution has also created a worldwide market for the seeds themselves. This has radically changed the relationship of corporate capital to agriculture because the key to controlling the Third World market for inputs is to control the seeds as well. Although the development of the HYVs was the product of government and 'philanthropic' funding, the chemical requirements of the HYVs has led to the agrichemicals industry establishing a global sales infrastructure which is now gaining increasing control over the seed market.[95]

So far as genetic resources are concerned the problem here is whether or not genetic diversity will be preserved under the intense commercial pressure of capitalist enterprise.[96] Many environmentalists believe that it will not, especially because of the 'patent-equivalent' legislation known as Plant Breeders' Rights (PBR). The PBR provides business with long-term security of investment since a plant variety cannot be 'stolen' by a rival firm. Consequently, this legislation has encouraged heavy corporate involvement in the seed industry. Most significantly, the PBR requires that varieties are sufficiently uniform to be distinctly identifiable as belonging to a particular owner/firm. Moreover, only varieties certified as having such properties may be sold under the legislation.[97]

The law is, therefore, an incentive for companies to produce exceedingly uniform varieties. Environmentalists may well be right in arguing that these conditions are a serious threat to genetic diversity but the full implications of widespread commercialisation of plant breeding remains uncertain.

Conclusion

The Green Revolution as technology and development strategy was formulated by a small number of powerful economic and political groups. Through undemocratic financial means they sought to modernise Third World agriculture with the expressed aim of reducing or eliminating hunger. The Green Revolution has succeeded in modernising much of Third World agriculture but it has entirely failed to reduce hunger.

There is no doubt that the Green Revolution has led to a widening of inequalities between rich and poor farmers and between landowners and landless labourers in many Third World agro-systems. This is because the rich farmers and landowners had the resources to benefit more substantially from Green Revolution technologies than the poor farmers and the landless labourers. However, this does not *necessarily* imply that the poor farmers and landless labourers did not also gain from the Green Revolution even if only fractionally. The evidence on this matter is conflicting. Based on the evidence available the 'most positive view' of the Green Revolution is that it has widened inequality between the rich and poor but only because the poor have benefitted less than the rich and it has not led to increased mechanisation and associated unemployment. Modernisation theorists might see this as the 'take-off' of Third World agriculture. The 'most negative view' is that the Green Revolution has made the rich richer and the poor poorer, contributing to unemployment, destitution, increased exploitation and poverty, more environmental hazards and hunger. Neo-Marxists might see this as the accumulation of capital by the rich entrepreneurial capitalist class of farmers at the expense of poorer farmers via the exploitation of landless labourers.

Advocates of the most positive view tend to ignore the environmental implications of the Green Revolution especially if their analysis is rooted in conventional economics. It follows that the most positive view must be weighed against environmental costs such as the pollution created by fertilizers, the toxicity of pesticides especially to landless labourers and the neglect of conservation strategies for genetic resources. It is surely evident that *even* the most positive view does not strongly recommend the Green Revolution as a desirable development strategy against hunger? At *best* it essentially confirms the socioeconomic position of the poor except at a slightly elevated level of poverty. Is this really a developement strategy worth defending especially in view of the many associated environmental costs? Though the HYV technology may be genuinely able to benefit poor farmers, the Green Revolution offered the poor no way out of being exploited, oppressed and powerless. This is important because these are all factors likely to make people vulnerable to undernutrition.

It is sometimes suggested that the Green Revolution has failed to reduce hunger because population growth has so markedly increased the number of people who go hungry. But this is as much an indictment as an excuse since any viable development strategy against hunger should be able to have

a clearly identifiable impact despite population growth. More importantly, the Green Revolution did not fail to reduce hunger just because of population growth; it failed because, as Bayliss-Smith has put it, it 'has not been revolutionary enough'.[98]

The most plausible explanation for the failure of the Green Revolution to reduce hunger is that it put technology at the centre of ambitions to bring about changes which needed to be of a fundamentally social and political nature. In this sense it was a *technocratic* vision as one development analyst reflected:

> Twenty years ago there was a very strong belief that many technical solutions were already known and that the real difficulty was getting them adopted. We thought that solutions were all in bottles in the shelf. Now we've come more and more to the feeling that we don't have that shelf-load of technology.[99]

The supporters of the HYVs have been right to emphasis that it is not the technology *per se* which has failed to benefit the poor but rather the system into which it was introduced. However, the sensible way to address this problem is surely not to defend vigorously the continuance of the technology but to begin to alter the power relations in the society which keep most people poor, hungry and exposed to hazardous chemicals. Rockefeller himself seems to have been aware of the limitations of the Green Revolution for he has been quoted as declaring: 'We have done little for the poor'.[100]

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