New Wheat Varieties, Poor Producers and Poor Consumers

Derek Byerlee and Larry Harrington
Economics Program
CIMMYT, Mexico.

February, 1982

Draft paper prepared for presentation at the Conference of the International Association of Agricultural Economists, Djakarta, Indonesia, August, 1982. Views expressed here do not necessarily represent those of CIMMYT.

NEW WHEAT VARIETIES, POOR PRODUCERS AND POOR CONSUMERS

Introduction

The distribution of the benefits of new agricultural technologies is the subject of continuing controversy, especially following the widespread adoption of new wheat and rice varieties in developing countries over the last 10-15 years. This paper is motivated by the popular belief that the introduction of the new wheat varieties has benefited larger farmers at the expense of the poor.[1/] We believe that the available evidence on the impact of the new wheat varieties overwhelmingly supports a quite different conclusion - that the poor have benefited substantially from these new varieties. Here we summarize evidence on only two aspects of the distribution of benefits from new wheat varieties; a) the distribution of benefits to poor producers relative to larger producers, and b) the distribution of benefits through market price effects to poor consumers relative to higher income consumers.[2/] Conceptual issues in analyzing these benefits are discussed and empirical evidence, especially new evidence appearing since 1975, is presented from Mexico, India and other countries where the new wheat varieties are widely used.

The New Wheat Varieties and Poor Producers

Conceptual Issues in Analyzing Technological Change by Farm Size

An analysis of the impact of new varieties should begin with a knowledge of their biological characteristics and how these interact with such specific characteristics of small farmers as subsistence production, risk aversion and capital scarcity. By far the greatest controversy with respect to the new wheat varieties surrounds the question of interactions of variety and intensity of input use and their implications for small farmers who may not be able to operate at higher levels of inputs because of capital scarcity or lack of access to purchased inputs. Four cases of variety by input interaction are shown in Figure 1. The prospects of developing varieties that give substantial increases in productivity independently of changes in input use - Case 3 and Case 4 - are improbable except where pest and disease resistance is the major breeding objective or an earlier maturing variety allows increased cropping intensity. Through history, productivity increases have largely resulted from increased input levels and improved cultural practices sometimes independently of varietal changes. New varieties then exploit positive interactions between variety and higher input use - Case 2 and Case 1. Increased productivity among small farmers then depend in large part on increasing input use. For small farmers, Case 2 will be preferable to Case 1, since the new variety can be adopted independently of a package with higher input levels, allowing the farmer to benefit in the short run while input levels are increased gradually over the long run.

The final impact of a new variety on the distribution of benefits by farm size depends on three factors; a) time lags in adoption by different size farmers, b) final level of adoption of the new variety by farm size, and c) productivity of the new variety when adopted by different size farmers. Note that a "scale neutral" variety that is widely adopted with equal productivity by all farm size groups will result in equal relative distribution of benefits but greater absolute gains to larger farmers because they control a larger land area.

Agronomic Characteristics of the Semi-Dwarf Wheat Varieties

Much of the criticism of the new varieties arises out of a misunderstanding of their agronomic characteristics and the interaction of these characteristics with input use. It is widely believed that breeders of the new varieties have developed varieties represented by Case 1 in Figure 1 when they should have emphasized Case 4 in order to directly benefit small farmers.

Although the semi-dwarf wheat varieties have often been described as a "quick technological fix", their development was based on nearly 20 years of research which preceded their release in Mexico. This earlier work gave initial priority to disease resistance, especially stem and leaf rust, which was the factor immediately limiting productivity at that time in the most important wheat areas of Mexico. The development of semi-dwarf wheat varieties helped overcome the next major factor limiting yields - the inefficiency of dry-matter conversion to grain and heavy lodging as management intensity increased. These varieties greatly increased ability to respond to higher fertility levels and also increased efficiency of nitrogen use, even at relatively low levels of application (Fischer and Wall (1976), CIMMYT (1981)).

The semi-dwarfs were developed and diffused under irrigated conditions which characterize well over half the bread wheat produced in developing countries. However, evidence from widespread testing of the semi-dwarfs under rainfed conditions indicates that in general, their higher yield potential more than compensates for any lack of drought resistance (e.g. Laing and Fischer (1977)). Their recent widespread adoption under rainfed conditions is further evidence of these varietal characteristics.

The new wheat varieties, then, tend to conform to Case 3 of Figure 1, in the sense that they have superior disease resistance, and Case 2 in their interaction with higher input level, particularly soil fertility and moisture availability. That is, agronomically they should be appropriate to small farmers but higher input levels are needed for significant productivity increases. There is little, if any, indication that they conform to the undesirable Case 1.

Adoption and Productivity by Farm Size

Evidence from Mexico: The Yaqui Valley. The introduction of the semi-dwarf wheat varieties in Mexico in the early 1960s combined with improved cultural practices, resulted in almost a doubling of wheat yields from 1960 to 1970. Until recently the only detailed study of the impact of the new wheat varieties in Mexico was provided by Hewitt (1978) whose work in the Yaqui Valley has been widely cited by critics of the new wheat varieties. According to Hewitt, the release of these varieties created substantial hardship for the ejido sector - the units created by the land reform program in Mexico and generally recognized as the "small farmer" sector. The official bank serving the ejido sector provided incorrect inputs or delivered imputs late and failed to give adequate technical advice (Hewitt (1978)). Because the ejido farmer was not able to effectively use the new inputs, his yields lagged well behind those of large farmers. As a result, ejido farmers became indebted to the credit bank, sold-off many of the inputs to large farmers and eventually rented out their land to large farmers. Hewitt concluded that this process resulted in 80 percent of the ejido farmers giving up control of their land so that land was eventually concentrated in the hands of a few farmers with 500 ha or more.

In 1981, ten years after Hewitt's field work, we conducted a survey of over 100 farmers in the Yaqui Valley and reached quite different conclusions (Byerlee (1982)). In the ejido sector, we estimated that a maximum of 20 percent of farmers were renting out their land. We also found a surprising number of small private farmers with similar farm size to that of the ejido sector. Finally, although we encountered differences in the wheat production technologies between small and large farmers, these differences were not large and resulted in a relatively small yield advantage of 10 percent to large farmers.

The question arises as to why such large differences exist between these two studies conducted ten years apart. It seems that Hewitt's assessment of the situation 10 years earlier is somewhat overstated. In one widely cited passage, she notes that the yield gap between the ejido sector and private farmers increasingly widened through the 1950s and 1960s, in contrast with the 1941-45 period when yields in the ejido sector were similar to private farmers. What she fails to point out - although she present the data - is that yields in the ejido sector almost quadrupled from 0.8 ton/ha in 1941-45 to 3.7 ton/ha in 1970!

Nonetheless, there is no doubt that problems with the official credit bank and lack of an effective extension service slowed productivity increases in the ejido sector and that one of the major reasons for improved performance of this ejido sector in our 1981 survey is the better performance of the credit system (although problems still exist). Finally, the lower degree of land concentration that we observed is due in part to the land reform of 1976, when some 30 percent of private land held by the largest farmers was expropriated to be worked as collective ejidos with an average of 5 ha for each farmer.

We do not claim that income in wheat growing areas of Mexico is equally distributed - far from it. However, the great majority of farmers in the Yaqui Valley (90 percent) are farmers of the land reform sector or private farmers with 25 ha or less who together control well over half the land area - quite different from Hewitt's picture of a few large farmers of 500 ha or more. Moreover, the substantial inequality in income that currently exists between the bulk of the small farmers and the large farmers of 50 to 100 ha or more is due to land ownership, not productivity differences due to technology.

Evidence from India: The Punjab. There is little doubt that in the wheat-growing areas of India, small farmers adopted new wheat varieties with little if any lag behind large farmers (Dagupta (1977), Sen (1974)). New wheat technology was introduced through mass action programs in which participation of small farmers was actively encouraged (Sen (1974)). Evidence from various measures of productivity indicate that small farmers are using the new wheat varieties with similar or higher levels of productitivity. Productivity as measured by yields is similar in both small and large farmers (Pearse (1980), Talib and Majid (1976)). Farm income/ha is consistently higher for small farmers (Punjab Agricultural University (1976-81)). Finally, production function analysis of survey data from the Punjab indicates no differences in technical and economic efficiency in wheat production by farm size (Sidhu and Baanante (1979)).

The overwhelming evidence from the Indian Punjab is that small farmer incomes have increased substantially in the last two decades as a result of the introduction of the new wheat technology. Indeed there is good evidence that both incomes and consumption have become less concentrated over time (Ahluwalia (1978), Punjab Agricultural University (1976-81)). This seems to relate in part to reduced concentration of land holdings due to new land reform regulations in 1972 (Bhalla (1980)).

Evidence from Other Countries. Evidence from the Pakistan Punjab characterized by a higher degree of share tenancy, essentially parallels the experience in the Indian Punjab with all farm size groups rapidly adopting the new wheat varieties (Lowdermilk (1972), Khan (1978)). The semi-dwarf wheats have also been widely adopted under rainfed conditions from Turkey to Argentina. Wheat varieties with similar agronomic characteristics combined with increased irrigation and chemical fertilizer use have also rapidly increased wheat productivity in China. However, the most dramatic uptake of the new wheat varieties has occurred in Bangladesh from 1975 to 1981 when area in wheat increased from 100,000 ha to over 600,000 ha and wheat yields more than doubled. Over 95 percent of the area was planted with the semi-dwarf wheat varieties imported from India and Mexico - the majority on rainfed or residual moisture. Average wheat area sown was only 0.5 ha per farmer and about half the wheat was used for subsistence consumption (Swenson et al (1980)). Here the new wheat varieties grown with relatively low costs of inputs - fertilizer is the only major purchased input - have proven particularly appropriate to small subsistence farmers operating under moisture limiting conditions.

New Wheat Varieties and the Poor Consumer

Conceptual Issues in Analyzing the Distribution of Consumer Benefits

Increased production resulting from technological change directly benefits consumers to the extent that product prices fall (or at least rise less rapidly than they would without the production increase). The distribution of these benefits among different consumer income groups and especially to poorer consumers depends on the importance of the product in the diet of different consumer groups. It can easily be shown that for products that have an income elasticity of less than one (i.e. most basic food products), poorer consumers gain relatively more than higher income groups from a price decline.[37] If the income elasticity is less than zero (i.e. a basic staple of the poor), poor consumers gain both absolutely and relatively more than higher income groups. Additional benefits are derived from the increase in consumption of a commodity resulting from lower prices. This is determined by the price elasticity of demand at each income level (Pinstrup-Andersen (1979)).

Most analysts assume that increased production does indeed reduce real prices to consumers. Implicitly a closed economy model is used. In fact, food grains, especially wheat, are widely traded internationally and most developing countries are dependent on wheat imports. Hence an open economy situation may better represent national wheat markets. In an open economy which imports wheat, increased wheat production does not affect prices until self-sufficiency is reached. The market can then be regarded as a closed economy until prices fall to export price levels. In the import substitution stage, producers receive the bulk of the direct benefits as well as consumers of foreign exchange who are often higher income consumers. When self-sufficiency is reached, domestic prices fall and consumers directly benefit. However, in both the open and closed economy case, government intervention in the food grain market may modify the price effects of increased grain production.

Evidence on Price and Consumption Effects

Evidence from Mexico. Wheat in Mexico is the second cereal after the basic staple, maize. As incomes rise, consumption of wheat products - largely bread - increases and tend to substitute for maize products. However, except for the poorest five percent of the population, the share of total family expenditure which goes for wheat products is slightly higher for the poor, indicating that a decline in real prices of wheat products would have a slight relative advantage for the poor (Byerlee and Harrington (1982)).

During the last two decades, Mexico has actively participated in the international wheat market. With rapid increases in wheat production during the 1960s, Mexico was converted into a wheat exporter from

1964 to 1970 when up to one-third of its production was exported. In the 1970s, Mexico has consistently been a wheat importer for up to one-third of its consumption needs.

Over the period 1961-63 to 1978-80, real prices of wheat paid to producers fell by 29 percent and real prices of wheat flour to bakers (which correlates closely to bread prices) decreased by 40 percent reflecting an increasing consumer subsidy on bread products. At the same time, the real price of imported wheat in 1978-80 converted to Mexican pesos at the official exchange rate was unchanged from the base period, 1961-63. However, Figure 2 shows that domestic wheat prices have tended to closely follow the import price, especially during the 1960s when Mexico was a wheat exporter.[4/] The correlation between real domestic and import prices during this period is 0.9. In the 1970s, government policy has reduced the effect of the sharp fluctuations in import prices and has kept producer prices lower than import prices although still reflecting trends in import prices. Overall, the evidence points toward an open economy situation for the Mexican wheat sector, although the policy of reducing domestic prices relative to import prices in the 1970s may have been stimulated by the wheat surplus situation in the 1960s.

Evidence from India. The introduction of the semi-dwarf wheats in 1967 resulted in even more rapid increases in India's wheat production - production doubled in only five years. The complexities of the Indian food marketing system make it difficult to determine to what extent increased wheat production has influenced real prices to poor consumers. Wheat consumption in rural areas is absolutely and relatively more important for middle income consumers. The largest share of consumer expenditure on wheat occurs in the second and third quintile of rural income distribution (Byerlee and Harrington (1982)). In urban areas, higher income families consume more wheat but wheat as a percentage of total expenditure is higher in poorer households reflecting the importance of wheat in food grains distributed through subsidized ration shops to poorer consumers. Hence any reduction in the real prices of wheat should be expected to have relatively higher benefits for poorer urban consumers.

A large part of the dramatic increase in wheat production from 1967 to 1972 was used to substitute for imports. Over the last two decades, India has reduced dependency on wheat imports from 29 percent of its consumption in 1961-65 to virtual self-sufficiency at the end of the 1970s. Over the same period, per capita wheat consumption has increased at the rate of 2.0 percent per year while per capita consumption of other major cereals has remained steady or declined.

Over the period, 1961-63 to 1976-78, the real price of wheat to consumers through subsidized ration shops increased by 10 percent while

the real producer price for government procurement increased 3 percent and the real price of wheat imports (at the official exchange rate) increased by 26 percent. The consumer price for wheat increased particularly sharply during the period 1966 to 1970 when wheat production was growing rapidly but this reflects in part the substitution of locally produced wheat for imports, much of which were obtained as food aid in the early 1960s.

Krishna and Chhibber (1981) in a detailed econometric analysis of the Indian wheat economy, concluded that although the Indian wheat economy was sensitive to the import price of wheat, the effect of a change in import prices on domestic prices was negligible. Thus unlike Mexico, the Indian wheat economy might be regarded as largely a closed economy with a significant degree of modification by government policy.

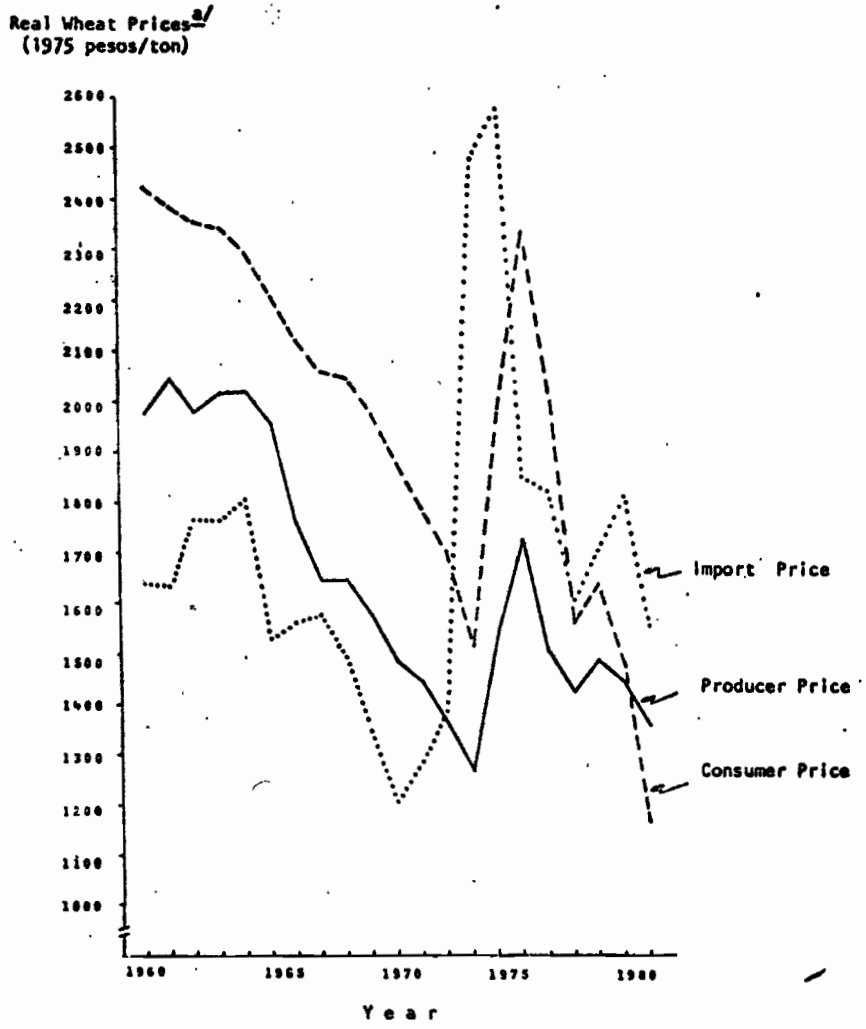
Further evidence on the consumer effects of the increased wheat production are provided by comparison of consumer expenditure surveys from 1961/62 and 1973/74 (George (1980)). Although per capita cereal consumption apparently declined over this period in response to decreasing real per capita incomes, per capita wheat consumption increased substantially. This increase was greatest in rural areas, especially among the lowest income group who tended to substitute wheat for rice. In urban areas, per capita wheat consumption increased little but wheat increased its share of cereal consumption, especially at the expense of coarse grains. To some extent, these changes in cereal consumption reflect changes in relative prices. In urban areas, wheat showed the smallest increase in prices among major cereals. In rural areas, the increase in wheat prices was lower than rice prices. The increase in wheat consumption by the poor in rural areas, probably reflects the rapid expansion of wheat production in poorer areas of India such as Bihar and West Benegal. Thus, overall, there are indications that increased wheat production in India has benefited both poor rural and urban consumers.

Conclusions

Critics of the impact of the new wheat varieties have correctly drawn attention to the fact that technology does not solve rural problems rooted in long-standing social inequities. They have also highlighted the need for agricultural institutions to efficiently serve all classes of farmers - not just the large and influential. Nonetheless they have done a disservice by claiming that the new varieties have increased rural poverty and inequality. Small farmers have gained substantially from the new wheat technology - in some cases relatively more than large farmers. The critics have also been misleading in characterizing the new varieties as input dependent and raising the prospect that new varieties can be developed for low input conditions that will significantly contribute to small farmer development. Development of varieties for some low input conditions, especially moisture and fertility, is likely to give relatively small gains at a high cost compared to efforts to improved cultural practices through greater use

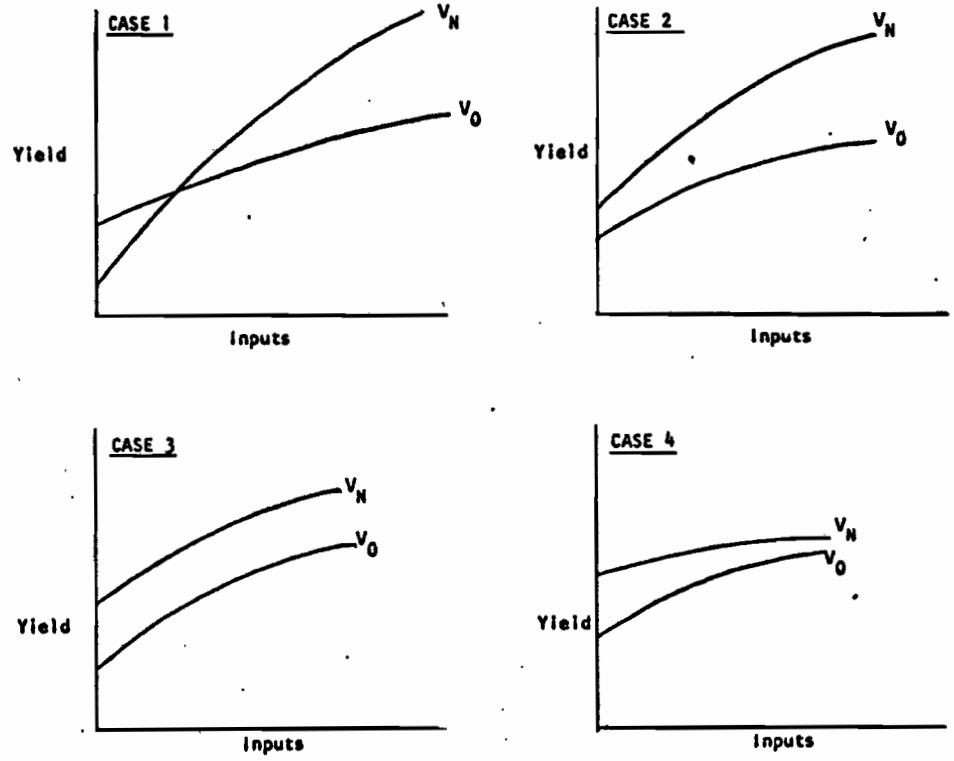
of purchased inputs such as fertilizer. Agricultural development, whether it is the small subsistance farmer of Bangladesh or the commune farmer of China is characterized by increased mangement intensity usually associated with greater use of capital per unit of land area in land scarce areas. The new wheat varieties by providing a dramatic jump in input responsiveness - especially water and fertilizer - have served as a catalyst both to higher use of purchased inputs by farmers and to government institutions to provide the appropriate inputs. In less favorable environments, considerable investment in research, especially on-farm research is needed to develop improved agronomic practices if productivity is to be increased. Finally, in both the wheat growing areas of India and Mexico, there have been significant shifts in land ownership toward small farmers associated with land reform programs of the 1970s. One might speculate that sharp increase in land values as a result of the new technology has in part stimulated pressure from the landless for these reforms.

Rapid increases in wheat production do not necessarily translate into cheaper food for the poor consumer. In particular, wheat is the most important food grain in international trade of most developing countries. In both Mexico and India, the increased supply of wheat has in part being used to substitute for imports or to export. However, in both cases, the real domestic wheat price to producers and consumers has fallen significantly over the last two decades relative to the real price of imported wheat although in Mexico changes in domestic prices closely followed world prices. Wheat consumption has also increased relative to other cereals and this seems particularly true for the poorer consumer groups in India. Although these results at the country level are somewhat inconclusive, there is no doubt that the rapid and widespread increases in wheat production in the developing world and reduced wheat imports in many countries especially South Asia - has been large enough to affect world wheat prices. Since developing countries account for two-thirds of world wheat imports, reduced wheat prices have widespread benefits for consumers in many countries.[57]



a/ Import prices (cif Texas border) assumed to be equal to f.o.b. Gulf Ports price for US No. 2 Hard Red Winter wheat coverted to pesos at the official exchange rate. Producer prices are the average farm prices and consumer prices are the wholesale price of flour to bakers converted to wheat equivalent. The Mexican consumer price index was used to convert to constant prices.

Figure 1. Possible Cases of Interaction of Management and Variety on Yields
(V_0 = Farmer Variety, V_N = New Variety)



Footnotes

1/ See for example the recent book on the green revolution by Pearse (1980) and the plant breeding textbook by Simmonds (1977).

2/ For a more comprehensive review of this evidence, see Byerlee and Harrington (1982).

3/ This assumes that the income elasticity of demand is constant across income groups.

4/ A regression analysis with real import prices and a dummy variable to represent a change in government policy in the 1970s as independent variables explained 56 percent of the variation in real producer prices from 1957-1980, with both coefficients significant at the 1 percent level.

5/ The price of wheat in international trade has fallen relative to rice and coarse grains over the last two decades.

REFERENCES

Ahluwalia, M.S., "Rural Poverty in India: 1956/57 to 1973/74" In India: Occasional Papers. World Bank Staff Working Paper No. 279, pp 1-42. Washington, D.C., 1978.

Bhalla, G.S., "The Green Revolution in the Punjab" Seminar on Rural-Urban Transformation and Regional Development Planning, Nagoya, Japan. UNCRD, 1978.

Byerlee, D., "Irrigated Wheat Production in the Yaqui Valley, Sonora, Mexico: Farmers' Practices, Perspectives and Research Opportunities", Working Paper, CIMMYT Economics Program, Mexico, 1982 (forthcoming).

Byerlee, D. and L. Harrington, "The Impact of the High Yielding Wheat Varieties on Income Distribution, A Review of the Evidence", Working Paper, CIMMYT Economics Program, Mexico, 1982 (forthcoming).

Dasgupta, B., Agrarian Change and the New Technology in India, Geneva: UNRISD, 1977.

Fischer, R.A., and P.C, Wall, "Wheat Breeding in Mexico and Yield Increases", The Journal of the Australian Institute of Agricultural Science, September, 1976.

George, P.S., "The Changing Pattern of Consumer Demand for Food Grains in India", Indian Journal of Agricultural Economics; 35(1); 53-68, 1980.

Hewitt de Alcántara, Cynthia, "La Modernización de la Agricultura Mexicana, 1940-1970", Editores Siglo Veintiuno, Mexico, 1978.

Khan, D.A., 'New Technology and Rural Transformation: A Case Study of Pakistan's Punjab", Seminar on Rural-Urban Transformation, Nagoya, Japan. UNCRD, 1978.

Krishna, R. and A. Chhibber, "Policy Modeling of a Dual Grain Market: The Case of Wheat in India", Draft Paper, IFPRI, Washington, 1981.

Laing, D.R and R.A. Fischer, "Adaptation of Semi-Dwarf Wheat Cultivars to Rainfed Conditions", Euphytica 26; 129-139, 1977.

Pearse, A., Seeds of Plenty, Seeds of Want, Oxford: Clarendon Press, 1980.

Pinstrup-Andersen, Per, "Modern Agricultural Technology and Income Distribution: The Market Price Effect", European Review of Agricultural Economics, 6(1): 17-46, 1979.

Punjab Agricultural University, An Analysis of Income and Expenditure Pattern for Punjab Farmers. Annual Reports, 1975-76 to 1979-80.

Sen, B., The Green Revolution in India, New York: Holsted Press, 1974.

Sidhu, S. and C. Baanante, "Farm-Level Fertilizer Demand for Mexican Wheat Varieties in the Punjab", American Journal of Agricultural Economics; 61(3); 455-462, 1979.

Simmonds, N.W., Principles of Crop Improvement, London; Longman, 1977.

Swenson, C.G., et al, "A Survey of the Economics and Agronomy of Wheat Production in Jessore and Pabna District, 1978/79", Agricultural Economics Research Report 79-1, Bangladesh Agricultural Research Institute, Dacca, 1980.

Talib, B. and A. Majid, "The Small Farmers of Punjab", Economic and Political Weekly, June, 1976.