

**New Wheat
Varieties and the Small Farmer**

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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 the rich at the expense of the poor.¹ We believe that the available evidence on the impact of the new wheat varieties supports a quite different conclusion—that the poor have benefited

substantially from these new varieties. Here we summarize evidence on only one aspect of the distribution of benefits from new wheat varieties: the distribution of benefits to poor producers relative to larger producers.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.

Conceptual Issues in Analyzing Varietal Changes 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 characteristics specific to small farmers, such as subsistence production, risk aversion and capital scarcity. By far the greatest controversy with respect to the new wheat varieties surrounds the question of the interaction between variety and input use, and its 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 for developing varieties that give substantial increases in productivity independently of changes in input use (Case 3 and Case 4) are limited except where breeding for pests and disease resistance

can be substituted for use of pesticides or where an earlier maturing variety allows increased cropping intensity.³ Through history, productivity increases have largely resulted from increased input levels and improved cultural practices, sometimes independently of varietal changes. New varieties have contributed to productivity increases by exploiting positive interactions between variety and higher input use—Case 2 and Case 1. Increased productivity among small farmers then depends 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. However, in more favored areas (e.g.

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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 as well as evidence pertaining to effects on poor consumers, see Byerlee and Harrington (1982).

³ A pest resistant variety may exhibit a Case 4 response to pesticide inputs but still show a Case 2 response with respect to other inputs such as fertilizer.

where purchased inputs are already widely used or where water is readily available through irrigation), the relevant position of the Y-axis is shifted to the right and Case 1 may be indistinguishable from Case 2.

The 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 resource base.

Agronomic Characteristics of the Semidwarf Wheat Varieties

Much of the criticism of the new varieties arises from a misunderstanding of their agronomic characteristics. 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 semidwarf 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 most important factor immediately limiting yields in the wheat areas of Mexico. The development of semidwarf wheat varieties helped overcome the next major yield-limiting factor, the inefficiency of dry-matter conversion to grain and heavy lodging as input use increased. These varieties had a 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).

The semidwarfs were developed and diffused under irrigated conditions which characterize well over half the bread wheat production in developing countries. However, evidence from widespread

testing of the semidwarfs under dryland conditions indicates that their yield advantage is still positive, although small in drier areas (e.g. Laing and Fischer, 1977). Of course, the first semidwarfs were not adapted to all conditions. In particular they were susceptible to some diseases such as septoria, had short coleoptiles which were not suitable for sowing into residual moisture and in some cases provided less competition against weeds. Later released varieties improved on many of these deficiencies.

The new wheat varieties, then, tend to conform to Case 3 in Figure 1 in the sense that they have superior resistance to certain diseases, and to Case 2 in their interaction with higher input levels, particularly soil fertility and moisture availability. That is, 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.

The semidwarf wheat varieties, by greatly increasing response to moisture and fertility, were a breakthrough in increasing productivity in areas with generally adequate moisture, especially irrigated areas. In dryland areas, moisture is the critical limiting factor. This is most effectively overcome through changing cultural practices to more efficiently utilize available moisture (through weed control and fertility) and increased soil moisture conservation (through tillage techniques) (Bolton, 1980).

Adoption and Productivity by Farm Size

Evidence from Mexico: The Yaqui Valley. The introduction of the semidwarf wheat varieties in Mexico in the early 1960s, combined with increased input levels and 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 which served much of the ejido sector provided incorrect inputs or delivered inputs 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. The net result was that the 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 500ha or more.

In 1981, ten years after Hewitt's field work, we conducted a survey of over 100 randomly chosen 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 for large farmers.

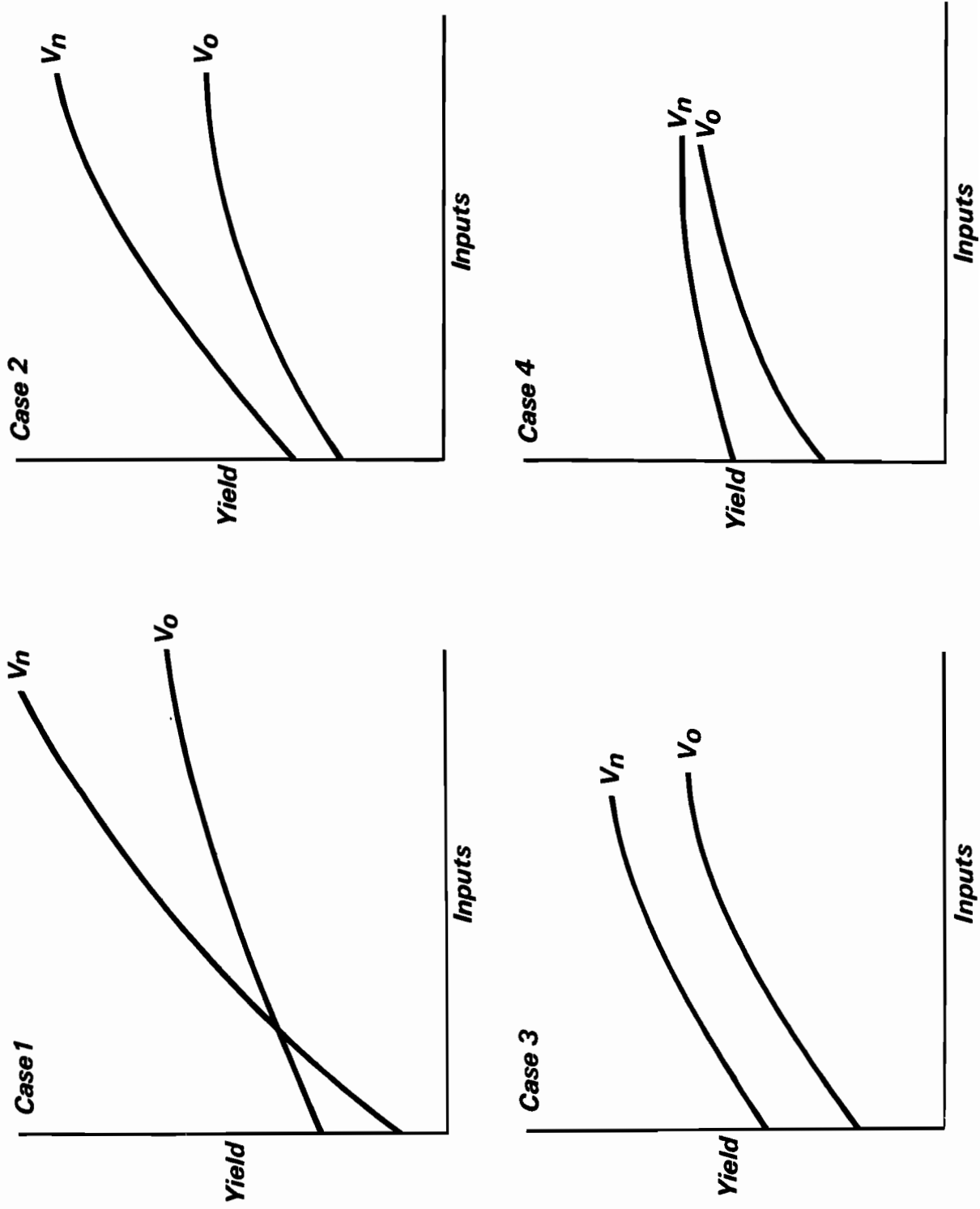
The question arises as to why such large differences exist between these two studies, conducted ten years apart. It seems that Hewitt's assessment of the situation 10 years earlier is somewhat overstated. In one widely cited passage, she notes that the yield gap between the ejido sector and private farmers widened increasingly 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 presents the data) is that yields in the ejido sector more than **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 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 of income that currently exists between the bulk of the small farmers and the large farmers (50 ha or more) stems from the size of the resource base, 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 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 levels of productivity similar to large farmers. Productivity as measured by yield 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).

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



The evidence from the India 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, an area characterized by a higher degree of share tenancy, essentially parallels the experience in the Punjab with all farm size groups rapidly adopting the new wheat varieties (Lowdermilk, 1972; Khan, 1978). The semidwarf 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 semidwarf 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.

Inter-regional Income Disparities. There has also been considerable discussion of widening inter-regional income disparities, especially in Mexico and India where much of the wheat is grown under irrigated conditions so that the new varieties, at least initially, were adopted in areas with relatively high incomes. This may widen relative income disparities but should not adversely affect absolute income levels in poorer regions unless public

investment allocation is distorted toward the better endowed regions by the new technology, or the increased production in better endowed regions reduces process to producers in poor regions. The latter case, however, benefits poorer consumers. Research whose specific objective is to increase the incomes in poorer regions might have had different crop priorities and emphasized different problems (e.g. improved management for maize in highland areas of Mexico).

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 improving small farmer welfare. Development of varieties for some low input conditions, especially low moisture and nitrogen fertility, is likely to give relatively small gains at a high cost compared to efforts to improve cultural practices through greater use of purchased inputs such as fertilizer. Agricultural development, whether it is with the small subsistence farmer of Bangladesh or the commune farmer of China, is characterized by increased management 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 with a farming systems perspective, 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 increases in land values as a result of the new technology has in part stimulated pressure from the landless for these reforms.

Increased production of wheat resulting from technological change also benefits poor consumers to the extent that a) wheat prices fall and b) wheat is relatively more important in the diet of poorer consumers than higher income consumers. Elsewhere we have shown that in Mexico, the real domestic wheat prices to producers and

consumers have fallen significantly over the last two decades relative to the real prices of imported wheat (Byerlee and Harrington, 1982). Wheat consumption has also increased relative to other cereals and this seems particularly true for the poorer consumer groups in India. Finally, the increased supply of wheat in both Mexico and India has been used in part to substitute for imports. There is no doubt that the rapid and widespread increase in wheat production in the developing world 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.

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