New Wheat Varieties and Farm Size

Much of the continuing controversy and misunderstanding on the effects of new wheat technology focuses on farm size. Specifically, there has been concern that the new technology may have undesirable distributional characteristics. Frankel (1971) asserts that the position of the small farmer, in areas in which the new technology is introduced, may suffer an absolute deterioration. Benefits are seen as heavily weighted in favor of larger farmers. Talib and Majid (1976) hypothesize the pauperization of small farmers, due to distress land sales that are seen as a consequence of the introduction of the new technology. There is, in fact, a considerable body of literature (part of which was noted in section 2.0) that deals theoretically with problems faced by small producers in the use of new technology.

The objective of this section is to review available evidence on the effect of new wheat technology on income distribution between small and large wheat producers. This review will include the influence of farm size on adoption of new wheat varieties and on input productivity. The evidence to be presented comes largely from India and Mexico.

Measures of Income Distribution

There are five major ways in which new technology can affect small farmer income, in rather an absolute or relative sense:

(1) Declining real income (pauperization): The real income of small farmers declines, due to an inability to compete profitably with large farmers and to consequent distress sales or mortgaging of farm land.

This hypothesis has been advanced by Frankel (1971), Benge (1977), Talib and Majid (1976), and possibly by Hewitt de Alcántara (1980) and Pearse (1980).

(2) Increasing real income, but an increased concentration of income in the hands of large farmers: Small farmers are better off in absolute terms but are worse off in relative terms. The Gini ratio (or some other measure of income concentration) indicates wider income disparities. 1/ Bhattacharya (1976) and Saini (1976) advance this hypothesis, considering that increased use of capital by large farmers may erase the scale advantage previously hold by small farmers.

(3) Increasing real income and a constant concentration of income, but higher absolute income gains by large farmers: Small farmers are better off in absolute terms and maintain their position in relative terms (constant Gini ratio). As income is seen as proportional to harvested area, however, large farmers enjoy larger real income gains. This hypothesis has been advanced by G.S. Bhalla (1978) and Sidhu (1979).

(4) Increasing real income and a decrease in the concentration of income (declining Gini ratio). Even in this case, of course, it is possible that large farmers enjoy larger absolute increases in income. This hypothesis may be seen in Raju (1976) and Rao (1975).

(5) Absolute increases in real income per farm are larger for small farmers. Small farmers are sufficiently more productive than large

1/ The Gini ratio is the most commonly used measure of income concentration (eg. Punjab Agricultural University, 1980). It is not the only such measure, nor is it necessarily the best. See Champernawne (1974) for a discussion of alternatives.

farmers to more than compensate for differences in harvested area.

In the following section, evidence will be examined from areas in India and Mexico in which new wheat technology has been adopted. Data on adoption rates and productivity by farm size will be presented, then changes in income levels and distribution will be reviewed, in order to see which of the five cases noted above actually prevails.

Evidence from India

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. In Ferozepur, Punjab, for example, no significant lag in adoption is apparent. (See Table 1). Sen (1974) observes a similar performance for all of Punjab (Table 2).

Three major reasons are often cited for the speedy adoption of new wheat varieties by small farmers. First, the characteristics of the varieties themeselves were favorable to small farmers. Dasgupta (1977) notes that the new wheat varieties, unlike the new rice varieties, have "acquitted themselves well in terms of productivity, pest resistance and culinary characteristics" (p. 353). Second, new wheat technology was introduced through such mass action programs is the IADP, in which participation of small farmers was actively encouraged (Sen, 1974, Randhawa et al, 197_). Finally, the importance of access to irrigation in this adoption decision tends to overwhelm other farm size related factors. As Sen (1974) points out, there is a surprising concentration of irrigated land in the hands of small and medium farmers (Table 3).

As small farmers in India adopted new wheat varieties, their productivity increased. Did small farmer productivity attain similar levels to that of large farmers? Many researchers find few farm size

Table 1.

Wheat: Percentages of Adopters of HYVs by Farm Size in Ferozepur.

Farm Size (ha)	1967-68	1968-69	1969-70	1971-72
		%		
Small (below 6)	14	43	89	100
Medium (6-14)	7	79	82	100
Large (over 14)	11	78	80	100

Source: Dasgupta, 1977.

Table 2.

Percentage Area Under HYV Wheat to Total Area Under Wheat, by Farm Size (Punjab).

Farm Size (acres)	1967-68	1968-69	1969-70
	%	%	
Below 5	68	69	96
5 - 20	56	75	96
Above 20	61	79	97

Source: Sen, 1974 (p.45)

Table 3.

Distribution of Irrigated Farms and Irrigated Land, by Farm Size.

Farm Size (acres)	% Distribution of Farms with Irrigation	% Irrigated Land
	%	
Below 5	62	29
5 - 15	28	40
Above 15	10	31
Total	100	100

related differences in productivity. Sidhu and Baanante (1979) find that "there are no differences in the technical and price efficiency parameters of small and large farms, that both classes of farms maximize profits and that there exist constant returns to scale in wheat production in the Indian Punjab..." (p.461).

Productivity as measured by wheat yields does not appear to specially favor large farmers. Even Pearse (1980), a major critic of new cereal technology, admits that "an attempt to establish an over-all relationship between yield per unit of land and size of holding under HYV's came to somewhat indecisive conclusion" (p.108). Dasgupta (1977) found that wheat yields in one area (Kota) were inversely related to farm size while in another area (Muzaffarnagar) there was no such correlation.

Talih and Majid (1976) encountered wheat yields in Punjab for the 1972-73 season to be only slightly greater for large farmers (more than seven ha). Larger farmers harvested 10 qq/acre; small farmers harvested 9 qq/acre. This conclusion is supported by Bhattacharya (1976). More recent yield data by farm size is not readily available. The evidence presented above, however, suggests that if large farmers enjoy a yield advantage in wheat production, it is relatively small.

Wheat yields are not necessarily the best measure of productivity. One advantage frequently attributed to new wheat tehcnology is that the intensity of cropping is facilitated. Increased land productivity may stem as much from increased cropping intensity as from increased wheat yields.

Evidence from India indicates no small farmer disadvantage in cropping intensity. 1/ Bhattacharya (1976) found, for 1972-73, a small

farmer cropping intensity index of 186, versus a large farmer index of 181. Chadha (1978) found a consistently inverse relationship between farm size and cropping intensity, for 1970-71.

A more satisfactory measure of productivity is that of net returns or "Farm Business Income" (FBI). FBI measures returns after the variable expenses of production have been deducted. Implicit in FBI statistics are crop yields, product price, input cost structure and, if desired, cropping intensity. FBI per land unit offers a way to compare net returns accruing to different farm size groups.

Data on "Punjab cultivators" from G.S. Bhalla (1978) show no significant difference in FBI/hectare over different farm sizes. (Table 4) more recent data gathered for Punjab state by Punjab Agricultural University (1976-1981) indicate FBI/ha that is consistently higher for small farmers (Table 5). These data do not support the concept of inferior productivity on the part of small farmers.

It is now appropriate to examine changes in the distribution of income, with emphasis on large versus small wheat producers. Earlier in this section, five possible changes in income distribution were presented. These five cases were:

1) Declining real incomes for small farmers (pauperization).

2) Increasing real incomes for small farmers, but an increased concentration of income in the hands of large farmers (Gini ratio rising).

1/ Kahlon (1974) and Rao (1975) argue, however, that small farmers previously enjoyed a large advantage in cropping intensity which is being erased by technological change.

Table 4.

Cropping Intensity, Value of Farm Output per Ha, and Farm Business Income per Ha, by Farm Size.

Farm Size (ha)	Cropping Intensity Index	Value of Farm Output/ha (Rs)	FBI/ha (Rs)
0-2.5	1.8	1601	724
2.5-5.0	1.8	1645	663
5.0-7.5	1.7	1568	758
7.5-12.5	1.7	1575	852
12.5-25.0	1.6	1457	786
> 25.0	1.5	1623	666

Source: G.S. Bhalla, 1978.

Table 5.

Farm Business Income per Ha, by Farm Size
(1975-76 to 1979-80)

Farm Size 1/	Year 1975-76	1976-77	1977-78	1978-79	1979-80
			Rs/ha		
Small	1882	2806	2853	2294	3463
Medium	1471	2021	2343	2528	2692
Large	1418	2023	2097	1994	2194

1/ Farm size definitions change over production zone. Small farmers were defined as 0 - 9 ha (cotton-wheat rotation), 0 - 5.5 ha (groundnut-wheat rotation), and 0 - 3.5 ha (paddy-wheat or paddy-maize rotations), respectively.

Source: Punjab Agricultural University, 1976-81.

3) Increasing real incomes for small farmers, with a constant concentration of income.

4) Increasing real incomes, with a declining concentration of income (Gini ratio declining).

5) Real income of small farmers increasing more rapidly than that of large farmers, per farm.

The first of the above cases (pauperization) can be immediately discarded. Talib and Majid (1976) specifically focused on this hypothesis in the context of Punjab. They found no evidence of distress land sales or distress mortgaging by small farmers. On the contrary, they found that small farmers were actively investing in new technology and were "doing rather well". S. Bhalla (1977) found no small farmer household or landless labor household in Haryana to have lost land by sale or foreclosure of mortgages. Leaf (1980) conducted two detailed studies of the same Punjab village, one in 1965 and the other in 1978. He found considerable improvement in the lot of the small producer. Brewal and Sidhu (1980) estimate that real income for the Punjab farmer increased 40% in 10 years.

If small wheat producers are better off in absolute terms, an examination of changes in the Gini ratio over time serves to measure changes in their income position relative to that of large producers. Ahluwalia (_____) found that the relative inequality of consumption (as measured by Gini coefficients) for Punjab and Haryana declined significantly between 1957-8 and 1973-4. More recent data from Punjab Agricultural University (1976-81) indicates that there has been a recent decline in the Gini coefficients for FBI per farm and FBI per capita. (Table 6).

Table 6.

Concentration of Farm Business Income, in the Punjab, 1975-76 to 1979-80.

Year	FBI Per Farm	FBI Per Capita
		(Gini Coefficients)
1975-76	.3985	.4453
1976-77	.3736	.4124
1977-78	.3659	.4043
1978-79	.3337	.3917
1979-80	.3432	.3993

Source: Punjab Agricultural University, 1976-81.

A common explanation for this phenomenon is that two factors are at work: (1) Large farmers appear to be increasing productivity faster than small farmers (although this is in the sense of "catching up" to small farmer productivity levels). This has been noted by Rao (1975), Chadha (1978) and Kahlon (1974), among others. (2) Nonetheless, land is being sold by large farmers and is being purchased by small farmers. This decline in the concentration of asset ownership apparently more than compensates for the differences in productivity growth noted above. This has been noted by Kahlon (1979), Rao (1975) and Randhawa (____).

In summary, although the productivity of large wheat farmers in the Punjab may have caught up with the productivity levels of small farmers, there is little evidence that large farmers hold a productivity advantage. The data presented above suggest that small producers' real incomes have increased and that the concentration of income in the hands of large producers has declined.

Evidence From Other Countries

New wheat varieties have been taken up by farmers in many countries other than Mexico and India. In China, for example, wheat varieties with similar agronomic characteristics, combined with increased irrigate and fertilizer, have rapidly increased wheat productivity. The semi-dwarf wheats have also been widely adopted under rainfed conditions from Turkey to Argentina.

Evidence from Pakistan supports the thesis that small farmers have benefited from the new wheat technology. Lowdermilk (1972), in a study of 30 villages in Pakistan's Punjab, found that small farmers adopted new wheat varieties at roughly the same rate as large farmers (Table 7). Salam (1981), using data from a nation-wide farm survey, found no

Table 7.

Percentages of Farmers in Pakistan Punjab Using Only Dwarf Wheat, by Farm Size (1966-71).

Farm Size Class (acres)	Year 66-67	67-68	68-69	69-70	70-71
			%		
2.5 - 7.5	3	15	48	58	61
7.5 - 12.5	2	5	39	48	46
12.5 - 25	0	4	30	47	47
25 - 50	1	19	39	49	52
Over 50	2	12	44	49	65
All Sizes	2	10	43	52	53

Source: Lowdermilk, 1972.

evidence that small farmers used less fertilizer or obtained lower yields than large farmers, when using new wheat varieties. He did find evidence, however, that suggests that larger farmers who "tractorize" tend to catch up to the high yield levels achieved by small farmers. (Table 8). Finally, Rochin (1972) found impressive advantages accruing to "small holders" due to the use of new wheat varieties plus fertilizer in "Barani" (rainfed) areas of N. Pakistan. The advantages he lists include large wheat yield increases, increased cropping intensity, and increased labor employment per land unit.

A more recent, and perhaps more spectacular example of the benefits to be gained from new wheat technology comes from Bangladesh. Area and yields of wheat, and as a consequence wheat production, have increased dramatically in this country since 1972-73 (Swenson, 1980). Recent data indicate wheat area as high as 600,000 ha for the 1980-81 season, with possibilities for considerable further expansion. This increase in area and yields is closely associated with a rapid expansion of the use of new wheat technology. (Table 9).

In two major wheat-producing districts studied by Swenson (1980), it was found that small farmers were overwhelmingly dominant - 90% of sampled farmers controlled 4 ha or less of farm land; indeed 70% of sampled farmers controlled 2 ha or less. Furthermore, little tenancy was found (75% of sampled farmers were full-owners). These small farmers were apparently willing to make the investment required for wheat production in expectation of acceptable returns. On an average total investment cost (including the value of family owned resources) of 4054 taka per ha of wheat, using new wheat varieties and fertilizer, sampled farmers not only repaid that cost, but earned on the average a further

Table 8.

Average Wheat Yields in Pakistan, by Power Source and Farm Size (1972-73, New Wheat Varieties Only)

Farm Size	Power Source	
	Tractors	Bullocks
	(maunds/acre)	
≤ 50 acres	27	29
> 50 acres	24	11

Source: Salam, 1981.

Table 9.

Wheat Area and Yields in Bangladesh
(1972-73 to 1978-79)

Year	Area			Average Yields
	HYV 1/	Local Varieties	Total	
	(000/ha)			(kg/ha)
1972-73	22	99	121	757
1973-74	29	94	123	899
1974-75	33	93	126	926
1975-76	88	62	150	1453
1976-77	116	44	160	1621
1977-78	157	31	188	1842
1978-79	236	29	265	1866

1/ New wheat varieties such as Sonalika, Pavon, Inca, etc.

Source: Swenson, 1980, p.65

return of 1667 taka per ha. Small farmers are, furthermore, consumers as well. It is interesting to note that the sampled farmers saved more than 60% of their production for home consumption! The evidence presented above suggests that small farmers in Bangladesh have gained significantly from new wheat technology.

A Related Issue: Mechanization Employment

Regardless of benefits to small farmers from new wheat technology, another issue is frequently raised by critics of that technology: Mechanization and employment. It is often claimed that new wheat technology is associated with mechanization of farms, (tractors and mechanical threshers) with a consequent loss of employment. Although farmers may benefit, permanent or casual hired labor opportunities may decline, to the detriment of landless laborers. Data from India's Punjab will be used to examine this proposition.

Was mechanization a necessary outcome, or an undesirable and unnecessary appendage to the use of new wheat technology in the Punjab? Day and Singh (___), argue in favor of the farmer. They point to increasing labor and bullock hire prices as a strong incentive to mechanize; they also note the rapidly increasing opportunity cost of land used for fodder production. Dasgupta (1977) explains this increase in labor and bullock hire costs as being directly due to technological change. The use of new wheat technology leads to increased labor requirements for irrigate, input application, weed control and, especially, harvest. Where the new technology facilitates the double-cropping of previously single-cropped fields, demand for labor increases dramatically.

The increase in the demand for labor in Punjab, accompanied by increases in wages paid to hired labor despite an influx into Punjab of laborers from other areas of India, has been documented by a variety of sources. G.S. Bhalla (1979) observed an over-all increase in employment, even on tractor farms. S. Bhalla (____) estimated that real wages in two prime "Green Revolution" districts (Ludhiana & Ferozepur) increased at roughly 30 - 50% over the period 1961 - 1977, despite a high growth rate in available workers. Pennant-Rea (1981) estimated that during the peak of the Green Revolution in Punjab, employment increased at roughly 30% per year, and noted the presence of numerous migrant workers from Bihar. Dasgupta (1977) concluded that on the whole, any decrease in employment due to mechanization was more than neutralized by the employment - increasing effects of high yields, a shift to labor-intensive crops, double-cropping, and large scale use of new inputs. Mechanization may best be seen, then, as a response by farmers to rising labor costs brought on by the increased labor requirements of new technology. 1/

1/ Biswanger (1978) comes to a similar conclusion, that mechanization is not directly responsible for increase yields and productivity, but can be an "engine of growth" under conditions of increasing labor and bullock costs.