NEW SEED VARIETIES AND THE SMALL FARM

M. Schluter

John W. Mellor

March, 1972 No. 72-21

Reprinted from
Economic and Political Weekly
Vol. VII, No. 13, Review of Agriculture. March 25, 1972

NEW SEED VARIETIES AND THE SMALL FARM

Michael Schluter

John W. Mellor

I

Introduction

It is generally accepted that a relationship exists between adoption of the new seed varieties and size of farm.[1] However, within this broad relationship there is considerable diversity in the adoption pattern between crops, seasons, regions and years. Owing to the complexity of the problem, we have looked at the results of a number of studies on a comparative basis, drawing primarily on the published reports of the Agro-Economic Research Centres (AERCs) and the Programme Evaluation Organisation (PEO). The data used refer to the period 1966-67 to 1968-69.

In this analysis. a farmer is defined to have 'adopted' if he has put any part of his acreage under the new varieties. We also consider on what proportion of acreage under the crop he uses the new varieties. The level of use of variable inputs may have more influence on income than the proportion of acreage put under the new varieties,[2] but unfortunately comparative data were not available for a study based on a package of improved practices.

II

Proportion of Farmers Adopting and Size of Farm

Table 1 summarises the results of the linear regression[3] between proportion of farmers adopting and farm size for 20 cases studied by the AERCs, and Table 2 for 50 cases studied by the PEO.[4]

[The authors are particularly grateful to G. M. Desai and B. M. Desai for comments on earlier drafts of this paper.]

Table 1: Estimated Linear Regression for Adoption Against Farm Size Using Agro-Economic Research Centre Data

Area by Crop**	Crop Year	Season	No. Obs	Unrestricted Model: Estimated Intercept	Unrestricted Model: Estimated Slope	Unrestricted Model: Estimated t Ratio	Unrestricted Model: Sum of Squared Residuals	Restricted Model: Estimated Intercept	Restricted Model: Sum of Squared Residuals
Paddy									
West Bengal 1	67	K	8	13.28	2.83	4.37*	11003.48	33.71	46103.80
West Bengal 2	67	K	7	52.40	4.61	2.87*	25258.20	69.85	66991.04
West Bengal 1	68	K	8	38.06	2.75	4.07*	12277.14	58.70	46100.47
West Bengal 2	68	K	7	86.29	0.97	3.57*	1161.32	90.34	4117.78
Andhra Pradesh 1	68	K	5	9.26	1.42	6.07*	16067.54	23.79	213239.3
Andhra Pradesh 2	68	K	5	14.33	1.04	2.90*	13041.97	20.79	49561.35
Andhra Pradesh 1	68	R	5	58.78	1.61	2.02	14919.48	69.36	35179.14
Andhra Pradesh 2	68	R	5	37.22	1.82	3.38*	29526.27	49.27	141711.4
Orissa	66	K	5	-4.17	4.81	3.87*	13988.19	12.82	83757.80
Bajra									
Gujarat 1	67	K	6	20.43	4.96	3.63*	15397.28	42.91	65994.57
Gujarat 2	67	K	6	-0.20	3.96	4.64*	10323.99	12.51	65882.68
Gujarat 3	67	K	6	6.18	5.43	7.77*	17480.28	28.63	281365.7
Gujarat 1	67	S	6	49.12	5.74	1.67	7203.09	61.86	12253.60
Gujarat 2	67	S	7	38.69	8.07	3.09*	16090.52	49.83	46954.38
Gujarat 3	67	S	7	6.62	4.99	5.71*	2323.54	16.03	17498.66
Gujarat 4	68	K	8	1.64	3.18	9.56*	4720.62	13.64	76683.74
Gujarat 5	68	K	8	11.57	2.85	6.23*	17994.03	44.89	134420.0
Maize									
Bihar 1	68	K	5	16.11	6.99	5.53*	5290.04	48.15	59175.49
Bihar 2	68	K	7	19.70	2.65	1.64	68778.54	28.29	105666.70
Wheat									
Rajasthan	68	R	8	29.15	0.90	3.54*	31489.80	44.40	97210.65

** The numbering of the districts is shown in Appendix A.

* Significant at 5 per cent level.

Sources: [2, 3, 6, 7, 9, 10, 11, 12, 14, 15].

Table 2: F Statistics to Test the Hypothesis that Adoption is Unrelated to Farm Size Using Data From the Programme Evaluation Organisation Reports

Crop	No. of Areas	No. of Obs	Observed F Statistic
Linear Model			
Paddy	16	82	6.91**
Bajra	8	39	44.16**
Maize	9	46	21.17**
Wheat	11	53	7.02**
Jowar	6	30	0.95

** Significant at 0.5 per cent level.
Source: Numbers 16-20 as listed in the references.

As expected, there is a significant positive relation between adoption and size of farm in most areas. In 17 of the 20 areas studied by the AERCs, the relationship is statistically significant, as it is in over half of those studied by the PEO. In no case was there a significant inverse relationship between adoption and size of farm. There is, however, considerable variability among regions and crops in the strength of the relation between farm size and adoption.

Rice

For East and West Godavari districts (Andhra Pradesh 1 and 2), studied by the AERCs [2, 3] adoption levels are much higher in the rabi than in the kharif season, as shown by the intercept terms in Table 1. The main reason for this is the greater profitability of the new rice varieties (especially IR-8) under the weather conditions of the rabi season. A second reason may be that the most successful of the new varieties, IR-8, was available for only one kharif season prior to 1968-69, but for two rabi seasons. Differences in adoption levels between farm size groups, shown by the size of regression coefficients, were similar between the seasons although the absolute level of adoption was much higher in the rabi season.

Results are similar in Sainthia Block (West Bengal I), [12, 13]. In 1968 the level of adoption was much higher than in 1967, but differences in adoption levels between farm size groups remained the same. But in Rampurhat-II Block (West Bengal 2), differences between farm size groups narrowed between 1967 and 1968. The reason for this is that, by 1968, almost all farms in the area studied had adopted the new varieties.

Data from these two districts suggest the more general hypothesis that differences in levels of adoption between farm size groups do not diminish until almost all farms have adopted. If adoption ceases to be closely related to farm size only when almost all farms have adopted the new varieties, income differentials resulting from the new varieties will persist longest in areas where the overall rate of adoption is slowest. Thus, it becomes critical to know what factors lead to a rapid overall rate of adoption.

PEO data [16, 18, 19, 20] confirm the central finding of the AERCs. Taking all the rice-growing areas together in the three years 1966-1968, adoption levels increase significantly with size of farm (Table 2).

Bajra

In three villages of Kaira district (Gujarat 1, 2 and 3) studied by the AERCs [7], differences in levels of adoption between size of farm groups were found to be uniformly greater in the summer than in the kharif season. This may be explained in terms of yield variability. Large farmers in this area have greater access to irrigation water, so that they experience lower yield variability than do small farmers in the summer, when there is greater dependence on irrigation. Thus the difference between farm size groups in their experience of yield variability is greater in the summer, leading to greater disparities in adoption levels.

The finding of the AERC reports, that adoption levels increase significantly with size of farm in each of the bajra areas studied, is supported by the PEO data [16,17] which show the same relationship in all the bajra-growing areas taken together (Table 2).

Paddy vs Bajra

Greater regression co-efficients for the bajra than for the paddy-growing areas studied by the AERCs indicate that differences in levels of adoption between farm size groups are greater in the former. A one-acre increase in farm size typically leads to a 5 per cent or more increase in the probability of adoption in a bajra-growing area in any given season or year, compared to 2 or 3 per cent in rice-growing areas. There are probably two main reasons for this. The first is a specification problem. Income per acre is considerably higher in paddy relative to bajra-growing areas. Therefore, credit and uncertainty cease to be constraints to adoption at a smaller farm size. Secondly, the increase in yield variability, in moving from traditional to new varieties, may be less in paddy than in bajra-growing areas owing to greater water control in the former. For this reason also, uncertainty will cease to be a constraint on adoption at a smaller farm size, and differences in adoption levels between farm size groups will be less.

Other Crops

In Kota district of Rajasthan, studied by the AERCs [9], the relationship between adoption of new wheat varieties and size of farm is not significant. However, in the wheat areas studied by the PEO, taken together, a significant relationship does exist [16, 17, 19, 20]. For maize, data from both the AERCs [15] and the PEO [16, 17] indicate that the proportion of farmers adopting is higher in the larger farm size groups (Tables 1 and 2).

Jowar is the only crop for which the proportion adopting is similar among size of farm groups. This emerges from the PEO data [16, 18, 19, 20], and is hardly surprising since hybrid seeds were introduced relatively late in the period under study, so that adoption on all size of farm groups was generally less than 10 per cent (Table 2).

III

Proportion of Acreage under the New Varieties and Size of Farm

Table 3 summarises the results of the linear regression between proportion of acreage under the new varieties and size of farm for 18 cases studied by the AERCs, and Table 4 for the five crops, aggregated across regions, studied in the PEO reports.

Rice

Predominantly negative co-efficients in both sets of data indicate that as farm size increases, the proportion of the crop's acreage put under the new varieties decreases.

In East and West Godavari districts, a greater proportion of rice acreage was put under the new varieties in the rabi than in the kharif season in all size of farm groups. This probably reflects conditions better suited to the new varieties in the rabi season. The inverse relationship between proportion of acreage under the high-yielding varieties and farm size is most marked in West Godavari district (Andhra 2) in the rabi season. Profitability of the new rice varieties was greater in West Godavari, and was also greater in the rabi than in the kharif season. This suggests that small farmers may be willing to commit themselves further to an innovation in situations where it is clearly profitable to innovate and uncertainty, in terms of yield variability, has been shown to be small.

Alternatively, large farms may be constrained from putting a large proportion of their rice acreage under the new varieties by problems of labour shortage. The new varieties are most clearly profitable in situations where their adoption facilitates a change to double-cropping. Double-cropping results in a tremendous demand for labour at the critical period of harvesting the first crop and sowing the second. Also the labour input for sowing, weeding, harvesting and threshing will be almost, if not completely, doubled. This may also give rise to acute problems of labour supervision. In these circumstances, the higher proportion under the new varieties on small farms would reflect the comparative advantage of such farms for a labour-intensive technology. Such a finding shows the urgency of removing other restraints on adoption by small farmers.

Taking all rice-growing areas together, we may suggest a more general hypothesis, viz, that after the 'experimental period' the new varieties are adopted to a greater extent by small farmers than by large farmers. If the experimental period for a new variety is thought of as three crop seasons, the districts in Andhra were studied in the post 'experimental' period with respect to IR-8 — the most successful of the new varieties —, whereas the other districts from West Bengal, Uttar Pradesh and Punjab, were studied within the experimental period [2, 3, 4]. In both the experimental and post-experimental periods, large farmers adopted on only about 20-30 per cent of their acreage, whereas small farmers adopted on a much higher proportion of their acreage in the latter period (35-80 per cent). This hypothesis is supported by data from the PEO reports [16, 17, 20], in which the differences between large and small farms in proportion under the new varieties are much greater in the rabi season of 1968, than in 1967 (Table 4).

The finding that over time small farmers increase their acreage under the new varieties is consistent with the hypothesis that credit is a constraint to adoption among

Table 3: Estimated Linear Regression for Proportion of Acreage Under the New Varieties Against Farm Size Using Agro-Economic Research Centre Data

Area by Crop	Unrestricted Model							Restricted Model	
	Crop Year	Sea-son	No. Obs	Estimated Intercept	Estimated Slope	Estimated t Ratio	Sum of Squared Residuals	Estimated Intercept	Sum of Squared Residuals
Paddy									
Orissa 1	66	K	5	30.34	-1.35	-1.90	1371.57	22.30	3024.11
West Bengal (1-2)	67	K	8	21.73	-0.10	-0.32	2750.63	20.83	2797.16
West Bengal (1-2)	68	K	8	22.23	0.37	0.93	4060.76	25.51	4648.68
Andhra Pradesh 1	68	K	5	34.52	-0.33	-1.17	3259.23	28.14	4752.49
Andhra Pradesh 2	68	K	5	40.82	-0.95	-3.51*	1827.89	29.60	9352.79
Andhra Pradesh 1	68	R	5	81.69	-1.61	-2.28	1743.57	69.62	4765.55
Andhra Pradesh 2	68	R	5	58.75	-0.21	-0.49	3976.20	56.40	4291.18
Uttar Pradesh 1	68	K	6	21.94	-0.25	-4.25*	150.14	16.65	829.65
Punjab 1	68	K	10	24.32	-0.13	-0.87	3179.35	20.86	3479.75
Bajra									
Gujarat 1	67	K	6	26.77	2.17	1.44	8285.41	39.42	12571.88
Gujarat 2	67	K	6	-0.15	3.37	4.05*	2341.65	21.85	11965.64
Gujarat 3	67	K	6	11.58	4.82	4.98*	13180.74	48.05	94998.01
Gujarat (1-3)	67	S	6	66.46	3.81	1.39	19164.68	74.05	28403.97
Gujarat 8	68	K	7	77.50	-0.15	-1.08	6256.88	73.33	7716.09
Maize									
Bihar (1-2)	68	K	7	44.24	-0.39	-1.77	898.35	41.73	1459.41
Gujarat 6	65	K	6	80.62	-0.80	-1.75	585.50	25.13	1036.29
Gujarat 7	65	K	7	49.38	1.36	1.30	802.78	54.54	1073.13
Wheat									
Rajasthan 1	68	R	8	53.76	-0.39	-1.32	47275.88	44.49	60943.30

* Significant at 5 per cent level.

Sources: [2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14, 15].

Table 4: Estimated Linear Regression for the Proportion of Acreage Under the New Varieties Against Farm Size, Using Programme Evaluation Organisation Data

Crop	Unrestricted Model							Restricted Model	
	Crop Year	Season	No. Obs	Estimated Intercept	Estimated Slope	Estimated t Ratio	Sum of Squared Residuals	Estimated Intercept	Sum of Squared Residuals
Paddy	67	K	6	19.13	-0.20	-1.12	13077.09	17.28	17173.62
Paddy	67	R	6	31.16	-0.29	-0.39	74479.78	29.12	77240.28
Paddy	68	R	6	63.82	-0.52	-0.74	63671.62	60.20	72377.09
Bajra	67	K	5	9.16	-0.01	-0.12	1847.58	8.87	1855.85
Bajra	68	K	6	37.00	-0.23	-0.94	15266.32	31.34	18619.77
Maize	67	K	6	23.66	0.00	-0.02	936.97	23.63	937.03
Maize	68	K	6	61.45	-0.46	-1.59	12925.94	51.71	21090.40
Wheat	67	R	6	22.94	0.21	1.63	7632.85	26.44	12699.50
Wheat	68	R	6	60.04	0.21	3.02*	2202.05	63.52	7226.00
Jowar	67	K	4	3.52	0.01	0.10	266.56	3.69	267.93
Jowar	67	R	5	0.45	0.10	2.76*	150.87	3.15	533.20
Jowar	68	K	5	35.59	-0.24	-0.77	13406.87	28.91	16045.85
Jowar	68	R	6	36.23	-0.44	-1.46	12717.63	25.09	19507.24

Significant at 5 per cent level.
Sources: [16-20].

small farmers. Having obtained higher yields on acreage under the new varieties in the experimental period, small farmers will be able to purchase a greater quantity of variable inputs in the next period and expand their acreage under the new varieties. A second hypothesis, also consistent with these findings, is that uncertainty is the primary constraint to adoption among small farmers. Once those small farmers, who are able to face the uncertainty initially, have experience in methods of cultivation of the new varieties, they put a greater proportion of their acreage under the new varieties.

Bajra-Growing Areas

In bajra-growing areas studied by the AERCs [7, 8], there is an apparent contradiction in terms of adoption behaviour. All the three villages in Kaira district, discussed earlier, have positive regression co-efficients — indicating that the proportion under the hybrid varieties increases with farm size. In contrast, the two talukas from Ahmedabad district have negative regression co-efficients, indicating that as farm size increases, the proportion of acreage under the high-yielding varieties decreases. The explanation may lie in the degree of dependence on the crop for income. In Kaira district, the large farms have a larger acreage under bajra than small farms; but in Ahmedabad district, large farms have a smaller acreage under bajra than small farms, owing to the possibilities of alternative cash crops such as cotton and groundnuts. In both districts, the correlation between total acreage under bajra and acreage under hybrid bajra was significant at the 1 per cent level. This suggests that the greater the degree of dependence on a crop for income, the greater the proportion of acreage put under the new varieties.

Data from the PEO reports [16, 17] do not show a significant relationship between proportion under the new varieties and size of farm for bajra (Table 4). It is possible that co-efficients were positive in some areas, and negative in others, cancelling each other to produce this result.

Maize, Jowar and Wheat

For maize and jowar crops, there is not a significant relationship between proportion of acreage under the new varieties and size of farm. But, for wheat, the relationship is significant (Table 4). In contrast to rice, large farmers put a greater proportion of their wheat acreage under the new varieties than small farmers. The new wheat varieties are both labour and capital intensive, but not to the same extent as the new rice varieties. When the new rice variety facilitates a change to double-cropping, both variable cash costs and labour inputs will be virtually doubled. Data from a small sample of wheat growers in Kaira district indicate that capital and labour utilisation on the new wheat varieties was greater by a margin of 20 per cent.[5] The increased labour demand resulted mainly from the additional requirements for harvesting and threshing. The greater labour requirement for the new varieties does not seem to have been a disincentive to large wheat farmers putting a high proportion of their acreage under the new varieties.

For all crops, the PEO data show a remarkable increase in the proportion of acreage put under the new varieties by adopters between 1967 and 1968. (See intercept co-efficients, restricted model, Table 4).

IV

Tenancy, Irrigation and Credit as Factors Affecting Adoption

In this section, we consider the validity of our restricted model, relating adoption to size of farm, by analysing whether there are other factors related to both adoption and size of farm.

Table 5 summarises the results of the linear regression model for proportion of land owned against farm size in eight regions studied by the AERCs [7, 9, 11, 12, 14, 15]. F tests showed no significant relation between proportion of land owned and farm size in these areas.

All-India data are used to analyse the relationship between tenancy and farm size in districts studied by the PEO, since these districts are a random sample of districts in the whole of India. Data for the proportion of land owned by size of farm group is given in Table 6. Clearly, there is some relation between the proportion of land leased-in and farm size.

In Table 7, we examine the proportion of pure tenants by size of farm group, since those who own no land may be expected to have the greatest disadvantage in adoption. Small farm-size groups have the greatest proportion of pure tenants. Unfortunately, there are no data available in the reports used showing the relation between tenancy and adoption in India as a whole. However, if tenants are less likely to innovate, the relation between tenancy and farm size, noted above, is a factor underlying the relation observed between adoption and farm size in areas studied by the Programme Evaluation Organisation.

It is clear from Table 8 that there is no relation between the proportion of land irrigated and size of farm in the areas studied by the AERCs [2, 3, 11, 12, 14, 15]. In no case is there a significant regression co-efficient; however, we found that the proportion of land irrigated was not the same between adopters and non-adopters. Availability of irrigation was an important factor in determining whether a farmer adopted. In East and West Godavari districts, almost the entire acreage on all farm size groups is irrigated. However, differential rates of adoption are observed between farm size groups, as well as high rates of non-adoption in all groups.

These results suggest that a high degree of irrigation availability is a necessary, but not a sufficient, condition for adoption. Neither is it a sufficient condition to equalise rates of adoption between farm size groups. We may conclude that irrigation availability is not a factor underlying the relation between adoption and farm size in these areas, since we do not find a positive relation between irrigation availability and farm size.

Water control may be a factor in the relation between adoption and farm size. Moorti has shown that the degree of water control has an important influence on adoption behaviour.[6] If there is also a relation between water control and farm size, then water control is a factor explaining the relation between adoption and farm size. Unfortunately, data showing the degree of water control were not available for this study.

To analyse the importance of irrigation availability in the areas studied by the PEO, we examine in Table 9 data for the relation between irrigation availability and

Table 5: Estimated Linear Regression for Proportion of Land Owned Against Farm Size, for Adopters and Non-Adopters** Using Agro-Economic Research Centre Data

Area by Crop	Unrestricted Model							Restricted Model	
	Crop Year	Season	No. Obs	Estimated Intercept	Estimated Slope	Estimated t Ratio	Sum of Squared Residuals	Estimated Intercept	Sum of Squared Residuals
Paddy									
Orissa 1 A	66	K	5	75.08	1.64	2.03	1767.09	84.82	4194.11
Orissa 1 NA	66	K	4	75.85	3.13	3.83*	511.62	85.61	2133.93
West Bengal 1 A	67	K	8	87.11	0.56	2.98*	918.43	91.96	2280.67
West Bengal 1 NA	67	K	5	82.29	0.84	0.64	2012.97	85.12	2291.09
West Bengal 2 A	68	K	8	84.15	0.49	2.49*	994.07	88.50	2025.17
West Bengal 2 NA	68	K	5	93.21	-0.19	-0.38	179.75	92.46	188.29
Bajra									
Gujarat 1 A	67	K	5	98.24	0.02	0.02	583.29	98.33	583.33
Gujarat 1 NA	67	K	5	97.49	-0.05	-0.06	213.08	97.33	213.33
Gujarat 2 A	67	K	5	86.78	0.20	0.14	844.20	88.00	850.00
Gujarat 2 NA	67	K	3	89.84	-0.20	-0.03	4092.54	89.33	4096.00
Gujarat 3 A	67	K	5	90.82	0.80	6.65*	8.24	94.60	129.60
Gujarat 3 NA	67	K	3	106.57	-4.18	-1.99	494.99	96.30	2464.20
Maize									
Bihar (1-2) A	68	K	7	89.93	0.26	1.03	1216.37	91.64	1476.07
Bihar (1-2) NA	68	K	4	80.92	3.29	2.34	1280.58	90.31	2392.46
Wheat									
Rajasthan 1 A	68	R	5	66.09	0.22	0.35	2710.68	68.99	2824.52
Rajasthan 1 NA	68	R	5	88.23	-0.34	-0.41	4621.58	84.35	4882.18

** In the Table, A = Adopters, NA = Non-Adopters.
* Significant at 5 per cent level.
Sources: [7, 9, 11, 12, 14, 15].

farm size in India as a whole. In 1961, the proportion of farms with irrigation is similar between size of farm groups, excluding the extremely small and extremely large farms; but as farm size increases, the proportion of land irrigated on farms with irrigation tends to decline. However, since 1961, irrigation availability has increased considerably, notably by the installation of a large number of tubewells. This has occurred mainly on the larger farms,[7] which may have narrowed the differentials between size of farm groups noted above.

Table 6: Area Leased-In as a Proportion of the Total Acreage Operated, By Size of Farm Group, 1960-61

Size of Farm (Acres) (1)	Area Operated ('000 Acres) (2)	Area Owned ('000 Acres) (3)	Proportion Owned (3÷2)
0.1- 2.5	23320	19312	0.83
2.5- 5	41991	35990	0.86
5-10	69333	61095	0.88
10-20	78445	73023	0.93
20-50	79931	76624	0.96
50 and above	36565	34071	0.93

Source: National Sample Survey, No. 176, p. 49.

Lack of credit availability has often been cited as one of the major reasons for slower adoption on small farms. Therefore, we examined whether there was any relation between the proportion of cash expenditure met by the co-operatives and farm size, and whether adopters and non-adopters were similar in this respect.

Table 7: Proportion of Households Which are Pure Tenants By Size of Farm Group

Size of Farm (Acres) (1)	Total No. of Households (2)	No. of Households as Pure Tenants (3)	Proportion of Pure Tenants (3÷2)
0- 0.99	1067588	157334	0.15
1.0- 2.49	2263120	248069	0.11
2.5- 4.99	2191492	165817	0.08
5.0- 9.99	2023088	105806	0.05
10.0-14.99	838661	35775	0.04
15.0-29.99	822069	27270	0.03
30.0-49.99	260089	6325	0.02
Over 50	130013	5240	0.04

Source: Census of India, 1961, Vol. I, Part III (ii), pp. 18-19.

Table 10 shows the relation between the proportion of cash expenditure met by the co-operatives and farm size in eight regions studied by the AERCs [2, 3, 11, 12, 14, 15]. In only three of the regions is the slope co-efficient significantly different from

Table 8: Estimated Linear Regression for the Proportion of Land Irrigated Against Farm Size, for Adopters and Non-Adopters** Using the Agro-Economic Research Centre Data

Area by Crop	Crop Year	Season	No. Obs	Unrestricted Model: Estimated Intercept	Unrestricted Model: Estimated Slope	Unrestricted Model: Estimated t Ratio	Unrestricted Model: Sum of Squared Residuals	Restricted Model: Estimated Intercept	Restricted Model: Sum of Squared Residuals
Paddy									
Orissa 1 A	66	K	5	80.99	0.45	0.84	780.24	83.68	965.35
Orissa 1 NA	66	K	4	78.31	-0.51	-0.47	460.38	76.61	510.59
West Bengal 1 A	67	K	8	93.53	-0.49	-0.18	1987.31	93.10	1997.69
West Bengal 1 NA	67	K	5	83.29	1.72	2.73	469.10	89.09	1636.92
West Bengal 2 A	68	K	8	87.43	0.54	2.81	978.59	92.29	2263.11
West Bengal 2 NA	68	K	5	86.09	0.42	0.34	1077.86	87.75	1119.39
Andhra Pradesh 1 A	68	K	5	100.00	0.00	0.00	0.00	100.00	0.00
Andhra Pradesh 1 NA	68	K	5	100.00	0.00	0.00	0.00	100.00	0.00
Andhra Pradesh 2 A	68	K	5	99.95	0.00	-0.27	4.46	99.91	4.57
Andhra Pradesh 2 NA	68	K	5	98.81	-0.32	-3.31	144.19	96.08	670.29
Andhra Pradesh 1 A	68	R	5	100.06	-0.15	-0.13	74.73	98.97	99.29
Andhra Pradesh 1 NA	68	R	4	96.47	0.16	2.21	4.99	97.25	17.19
Andhra Pradesh 2 A	68	R	5	100.00	0.95	0.11	0.15	100.00	0.12
Andhra Pradesh 2 NA	68	R	4	100.13	-0.01	2.25	0.77	99.96	2.72
Maize									
Bihar (1-2) A	68	K	7	35.22	0.75	1.05	9674.72	40.11	11806.09
Bihar (1-2) NA	68	K	4	23.01	2.15	4.66*	68.97	29.15	818.62

** In the Table, A = Adopters, NA = Non-Adopters.
* Significant at 5 per cent level.
Sources: [2, 3, 11, 12, 14, 15].

zero at the 5 per cent level. All three co-efficients are negative — indicating that as farm size increases, the proportion of cash expenditure met by the co-operatives decreases. Such a result indicates that large farms meet cash expenditure from other sources; PEO data indicate that the greater part of total cash expenditure is met from farmer's own funds [19].

To the extent that small farms use co-operative credit when large farms use their own funds, small farms may have higher cost credit than large farms. If the cost of credit is important in adoption, the relation between cost of credit and farm size is a factor in the relation between adoption and farm size.

Adopters meet a far greater part of their cash expenditure from co-operatives than do the non-adopters. The proportion of cash expenditure met by the co-operatives for adopters and non-adopters in four of the areas studied is as follows (see intercept co-efficients for the restricted model in Table 10):

Area	Adopters	Non-adopters
	(Per Cent)	
Bihar	92	25
Orissa	48	6
West Bengal (in 1968)	61	34
Andhra Pradesh 2 (rabi)	33	5

These data indicate a close relation between use of co-operative credit and adoption. However, the line of casuality is not clear. Lack of access to credit may stop adoption; or lack of desire to adopt results in low need for credit and hence less use of co-operative credit. Data from the PEO reports indicate that a significantly greater proportion of those with large farms are members of co-operatives than those with small farms, and that a significantly higher proportion of adopters are members than of non-adopters [16].

In combination, the results of this analysis suggest that few of those with small farms obtain co-operative credit, but, those who do, meet a high proportion of their cash expenditure from this source. It is these farms which adopt the new varieties.

Table 9: Irrigation Availability and Farm Size in India

Farm Size Group (acres)	Ratio of Farms with Irrigation to the Total No. of Farms in Group	Ratio of Irrigated Acreage, Per Farm with Irrigation, to Average Size of Holding
0- 1	0.38	0.89
1- 5	0.48	0.63
5-10	0.48	0.54
10-15	0.46	0.46
15-25	0.45	0.39
25-50	0.44	0.29
50 and above	0.39	0.22

Source: Derived from the Sixteenth and Seventeenth Rounds Estimates of the National Sample Survey, 1959-61.

Table 10: Estimated Linear Regression for the Proportion of Cash Expenditure Met by the Co-Operatives Against Farm Size, for Adopters and Non-Adopters ** Using Agro-Economic Research Centre Data

				Unrestricted Model				Restricted Model	
Area by Crop	Crop Year	Sea-son	No. Obs	Estimated Intercept	Estimated Slope	Estimated t Ratio	Sum of Squared Residuals	Estimated Intercept	Sum of Squared Residuals
Paddy									
Orissa 1 A	66	K	5	59.78	-2.03	-2.10	2523.90	47.71	6245.21
Orissa 1 NA	66	K	4	4.96	-0.53	2.02	26.69	5.71	190.42
West Bengal 1 A	67	K	8	18.05	-0.60	-2.77*	1416.79	12.47	3223.64
West Bengal 1 NA	67	K	5	8.76	1.01	0.76	2090.88	12.16	2492.60
West Bengal 2 A	68	K	8	88.38	-3.11	-4.47*	12585.35	60.62	54537.87
West Bengal 2 NA	68	K	5	47.25	-3.24	-1.57	3018.84	34.45	5393.40
Andhra Pradesh 1 A	68	K	5	20.81	-0.16	-0.46	4852.25	17.78	5188.05
Andhra Pradesh 1 NA	68	K	5	22.19	-0.85	-1.55	3467.55	14.44	6261.27
Andhra Pradesh 2 A	68	K	5	13.39	-0.22	-1.62	438.44	10.85	821.61
Andhra Pradesh 2 NA	68	K	5	5.82	-0.08	-0.36	769.23	5.12	803.19
Andhra Pradesh 1 A	68	R	5	1.32	0.59	1.18	877.57	5.74	1282.34
Andhra Pradesh 1 NA	68	R	4	6.50	-0.27	-0.41	426.09	8.95	533.80
Andhra Pradesh 2 A	68	R	5	37.69	-0.41	-0.71	7047.78	33.16	8222.06
Andhra Pradesh 2 NA	68	R	4	2.11	0.23	0.34	999.55	5.25	1176.09
Maize									
Bihar (1-2) A	68	K	7	89.93	0.26	1.03	1216.37	91.64	1476.07
Bihar (1-2) NA	68	K	4	19.69	-1.76	4.75*	44.25	25.42	1543.37

** In the Table, A = Adopters, NA = Non-Adopters.
* Significant at 5 per cent level.
Sources: [2, 3, 11, 12, 14, 15].

V

Uncertainty

Two sources of uncertainty need to be distinguished for this analysis. When a new variety is first introduced, lack of knowledge of methods of cultivation and the crop's response to different weather conditions result in a high degree of uncertainty. Secondly, the variety itself may be more prone to disease, or more sensitive to weather conditions, than traditional varieties. The former source of uncertainty will diminish over time, but the latter will not. Either type of uncertainty may be a cause of differential rates of adoption between farm size groups. Analysis of data collected at the Indian Institute of Management in Ahmedabad have clearly brought out the point.[9] Data were collected for 99 farmers growing traditional bajra varieties, and for 58 growing hybrid bajra in Mehsana district, Gujarat, in 1966 [21]. Cobb-Douglas production functions were estimated for both varieties; inputs included land, seed, number of irrigations, manure, nitrogen, phosphorous, hired and family labour, all measured in physical units; yield in kilogrammes was the dependent variable. The regression explained nearly 60 per cent of the variation in yields for the traditional varieties, but only 30 per cent for the hybrid varieties. The low explanation for the latter suggests that yields fluctuated widely between farmers using similar input levels, which gives some measure of the uncertainty associated with the crop.

Less direct evidence for the importance of uncertainty in adoption behaviour is found in analysis of data from Thanjavur District, collected in 1966 [22]. Those with a non-farm occupation were found to put a significantly greater proportion of their acreage under ADT-27 than those without such a job. Those with such an occupation have a steady source of income which is unrelated to their farming activity; thus, they are far better equipped to face fluctuations in their farm income. This finding supports the hypothesis that uncertainty is a major barrier to adoption among farmers. It may also indicate that high costs of cultivation inhibit adoption of the new varieties. However, it may also indicate the greater availability of resources to finance the greater cash costs of the new varieties. In practice, the uncertainty and the resource factors probably reinforce each other.

VI

Conclusions

We have shown that, in the period 1966-67 to 1968-69, small farmers were lagging in adoption of the new seed varieties. If small farmers did not adopt the new varieties owing to the high costs of cultivation involved, we may expect differences in adoption levels between farm size groups to continue for an indefinite period in the absence of appropriate policy intervention. However, if the reason for non-adoption is the uncertainty attached to cultivation of the new varieties, the differences may diminish to some extent, without policy intervention, over time as experience with the new crop and increased knowledge about methods of cultivation reduce uncertainty.

The findings of this study are consistent with the hypothesis that either high cost of cultivation or uncertainty has caused differential rates of adoption between farm

size groups. This analysis has shown that small farmers rely heavily on co-operative credit. Credit is required for the purchase of variable inputs. It may also be used as a form of crop insurance, so that in the event of lower production, the farmer can meet essential consumption requirements without recourse to the moneylender. The importance of irrigation availability in adoption may reflect the importance of uncertainty, in that, yield variability is less on irrigated land, or it may reflect the greater availability of cash for the purchase of non-farm inputs on more highly irrigated farms, which generally have a higher income per acre. The fact that, in Thanjavur in 1966, those with non-farm jobs adopted the new varieties on a greater proportion of their land than those without, may also be used to support either the hypothesis that uncertainty is the critical constraint to adoption or that credit is the chief problem.

Credit and uncertainty are not entirely separable. Increased use of credit, used for the purchase of irrigation water and plant protection materials may reduce yield fluctuations and thus uncertainty. On the other hand, it may be uncertainty which makes credit a binding constraint. A small farmer might be quite willing to borrow from a moneylender to grow a new variety if the uncertainty associated with the venture could be reduced. Co-operative credit may be important in adoption because a co-operative is easier to appease than a moneylender in the case of a crop failure.

The joint problems of credit and uncertainty may also be relevant in the broader context of the overall cropping pattern chosen by the farmer. Many other high-income cash crops also involve a high cost of cultivation and a high degree of uncertainty. Vegetables, for example, involve a high level of cash inputs, and both the incidence of disease and market price fluctuations combine to cause very high income fluctuations from their cultivation. It is possible that the smaller proportion of acreage under cash crop on small farms is due to credit or uncertainty, or some combination of these factors.

This analysis has been largely oriented to the adoption problems of the small farmer. Particularly in the rice areas, among adopting farmers, the larger farmers seem to adopt on a smaller proportion of their acreage than the smaller farmers. This may well be due to problems of obtaining and managing labour. If that is the case, the solution lies in either reducing size of farms, increasing the mobility of labour, or mechanisation.

Notes

1. See, for example, Economic and Political Weekly, Volume V, Number 13, p. A-15, Number 14, p. 603.

2. See V. S. Vyas, D. S. Tyagi, and V. N. Misra, "Significance of the New Strategy of Agricultural Development for Small Farmers", Agro-Economic Research Centre, Sardar Patel University, 1968.

3. Because of unsatisfactory features of a linear regression model with a proportion as the dependent variable, the results were confirmed using a logit model.

4. In a regression framework, an omitted variable results in estimated co-efficients of included variables being biased. Therefore, we tested whether three factors thought to influence adoption — proportion of land owned, proportion of land irrigated and proportion of cash expenditure met by the co-operatives — were related to either farm size or adoption.

5. G. O. Parikh and R. D. Sevak, 'Relative Profitability of Improved and Deshi Wheat: A Case Study', Industrial March, January-March 1971, p. 48.

6. John W. Mellor and T. V. Moorti, 'Dilemma of State Tubewells', Economic and Political Weekly, Volume VI, Number 13, March 27, 1971, p. A-37.

7. For example see A. Rudra, A. Majid and B. D. Talib, 'Big Farmers of Punjab', Economic and Political Weekly, Volume IV, Number 39, p. A-143.

8. See also N. S. Jodha, 'Land-based Credit Policies and Investment Prospects for Small Farmers', Economic and Political Weekly, Volume VI, Number 39, p. A-143.

9. M. Schluter and R. Longhurst, "Suitability of the New Technology for the Small Farm: An Analysis of the Introduction of High-Yielding Rice and Bajra Varieties in Two Districts in India". To be published in the Occasional Paper Series, Department of Agricultural Economics, Cornell University. Analysis currently being completed at the Indian Institute of Management, Ahmedabad.

Sources of Data used in the Analysis

Published by the Agro-Economic Research Centre, Andhra University, Waltair:

[1] ____, Preliminary Report on the Study of the HYVP (Kharif 1968-69; Phase 1), November 1968.

[2] ____, Report on the Study of the HYVP, (Kharif 1968-69: Phase II), September 1969.

[3] ____, Report on the Study of the HYVP, (Rabi 1968-69: Phase III), December 1969.

Published by the Agro-Economic Research Centre, University of Delhi:

[4] P. V. G. K. Rao, "Economic Aspects of HYVP in Punjab", (A Study of IR-8 Paddy in Amritsar District, Kharif 1968-69), 1969.

Published by the Agro-Research Centre, Sardar Patel University:

[5] B. M. Desai, "An Evaluation of Some Aspects of the Hybrid Maize Programme in Dohad Taluka" (Panchmahals District, Gujarat), 1967.

[6] V. S. Vyas, D. S. Tyagi, V. N. Mistra "Significance of the New Strategy of Agricultural Development for Small Farmers", 1968.

[7] B. M. Desai and M. D. Desai, "New Strategy of Agricultural Development in Operation" (A Case Study in the Kaira District in Gujarat), 1968.

[8] V. S. Dharap, "A Study of the Hybrid Bajra Programme in the Ahmedabad District, Gujarat" (Kharif 1968-69), 1969.

[9] D. S. Tyagi and V. N. Misra, "A Study of the HYVP in the Kota District, Rajasthan" (Rabi 1968-69), 1969.

[10] N. R. Shah, "A Study of the Hybrid Bajra Programme in the Kaira District, Gujarat" (Summer 1967-68), 1969.

Published by the Agro-Economic Research Centre, Visva-Bharati, Santiniketan:

[11] B. K. Choudhury, "A Study of HYVP in the District of Cuttack, Orissa with Special Reference to Credit", February 1967.

[12] B. K. Choudhury, "A Study of HYVP in the District of Birbhum, West Bengal with reference to Kharif Paddy, 1967-68", March 1968.

[13] ____, Preliminary Report of the Working of the HYVP in the District of Saran, Bihar, 1966-67 to 1968-69 (Kharif). September 1968.

[14] M. G. Ghosh, "A Study of HYVP in the District of Birbhum, West Bengal with reference to Kharif Paddy, 1968-69", May 1969.

[15] B. K. Choudhury and G. Ojha, "A Study of HYVP in the District of Saran, Bihar with Reference to Hybrid Maize (Kharif) 1968-69", May 1969.

Published by the Programme Evaluation Organisation, Planning Commission, Government of India:

[16] ____, Report for the Kharif — 1967, August 1968.

[17] ____, Report for the Rabi 1967-68 — Wheat, October 1968.

[18] ____, Report for the Rabi 1967-68 — Paddy and Jowar, January 1969.

[19] ____, Report on Kharif — 1968, June 1969.

[20] ____, Report for the Rabi 1968-69 — Wheat, Paddy, and Jowar, November 1969.

Published by the Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad:

[21] D. K. Desai and D. A. Patel, "Hybrid Bajra in Gujarat State", Planning and Implementation in Agriculture, Studies on HYVP Series, Volume IV, 1967.

[22] M. Malya and P. P. Madappa, "Paddy (ADT-27), in Madras State", Planning and Implementation in Agriculture, Studies on HYVP Series, Volume I, 1967.

Appendix A

The districts have been numbered as follows in Tables 1, 3, 5, 8, 10.*

West Bengal 1: Sainthia Block, Birbhum District.
West Bengal 2: Rampurhat Block II, Birbhum District.
Andhra Pradesh I: West Godavari District.
Andhra Pradesh 2: East Godavari District
Gujarat 1: Piplag Village, Nadiad Taluka, Kaira District.
Gujarat 2: Khadol Village, Borsad Taluka, Kaira District.
Gujarat 3: Asodar Village, Borsad Taluka, Kaira District.
Gujarat 4: Nadiad Taluka, Kaira District.
Gujarat 5: Dehgam Taluka, Ahmedabad District.
Gujarat 6: Jambua Village, Dohad Taluka, Panchmahals District.
Gujarat 7: Gangarda Village, Dohad Taluka, Panchmahals District.
Gujarat 8: Ahmedabad District
Bihar 1 Baniapur Block, Saran District.
Bihar 2: Hawthwa Block, Saran District.
Rajasthan 1: Kota District.
Punjab 1: Amritsar District.
Orissa 1: Cuttack District.

* The different levels of aggregation reflect different levels of aggregation of the data in the reports.