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An Analysis of Factors Affecting the Adoption of Modern Varieties in Eastern Nepal

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AN ANALYSIS OF FACTORS AFFECTING THE ADOPTION OF MODERN VARIETIES IN EASTERN NEPAL

TILAK RAWAL*

ABSTRACT

The purpose of this study was to examine the factors affecting the proportion of a farmer's land planted to modern varieties of rice and wheat, and to evaluate resource use and productivity of modern varieties (MV) and local varieties (LV) of rice and wheat in the southern Kosi zone of Nepal.

Primary data sources used in this study were derived from a sample of 181 rice-growing farmers, and secondary data were obtained from institutions and the private sectors involved in rice marketing. Multiple linear regression was the principle analytical technique used in the analysis.

MV were found to be higher yielding than LV, and while total labour inputs were similar, the proportion of hired to total labour was significantly higher in MV than in LV production.

The educational status of the farmer, his exposure to extension and his historic experience were identified as significant factors influencing the adoption of MV. Cost of fertilizer, experience, area planted to MV, farm size and credit availability contributed to the between farm variability in the use of fertilizer.

INTRODUCTION

Countries have followed different agricultural strategies to accomplish the task of increasing food production to feed the day-by-day increasing population. By the early 1960s, expanding the area under cultivation was no longer a feasible option for increasing food production in most South and South-East Asian countries. Faced with this land constraint problem, planners and agricultural scientists started pleading for a wider diffusion of yield-increasing technology to combat the problem of food production when new tracts of agricultural land were less easily available.

Within South-East Asia, the adoption of new rice varieties has been most rapid in the Philippines. Contributing factors were increasing irrigation facilities, government emphasis on agricultural credit and extension and the existence of the International Rice Research Institute (IRRI) in the Philippines, the site, where the modern varieties were developed and initially evaluated (Mangahas 1970). At

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the other extreme, the adoption of MV has been minimal in Thailand due to a combination of low rice prices relative to fertilizer and a large proportion of the rice crop being grown in areas with no water control.

Regarding between farm variability in the adoption of MV rices, it is often argued that farms with larger cultivated areas are more likely to adopt MV than small farms (Rao 1954). However, this argument is often not substantiated. Many studies have found this variable not significantly related to adoption (Choi 1974, Anden and Barker 1973). Schluter (1971) found that small farms have a higher proportion of their land under new varieties than large farms.

In many cases, formal schooling of the farm operator and his exposure to extension have been found to be positively related with adoption. This indicates that the farmer's schooling plays a positive role in the transition from traditional practices to improved practices (Medigan 1962). Similarly, the farmers who participate in government extension programmes have a greater probability of adopting MV, both on irrigated and rainfed farms (Mangahas1970).

It has been shown in most cases that farmers plant MV rices on paddy fields which have relatively better drainage (Suh 1976) and some authors believe water management to be the single most important factor influencing the adoption of MV rices (Anden and Barker 1973).

Another important factor purported to explain the adoption of MV rices is the availability of credit to farmers. Many small farmers in Nepal do not have access to credit from institutional sources (Hagan 1976).

The adoption of MV rices is likely to be greater in the case of owner-operators. When a farmer is subject to capital rationing, while it may remain profitable for an owner-operator to grow MV rices, it may well be more profitable for the tenant farmer to grow local varieties (Shah and Flinn 1979).

Some studies have shown that the greater the time period from the introduction of new varieties, the greater the proportion of acreage put under new varieties in all farm size groups (Schluter 1971).

Since MV rices normally require more labour for seed-bed preparation, weeding and harvesting compared to local varieties (Suh 1976), the number of full-time working adults available in the household is taken as another factor which contributes to adoption. Farmers' taste preference for LV rices on the other hand, may be a factor retarding adoption.

In summary, the adoption of MV rices can be explained as being a result of the interaction of two sets of factors: (a) bio–physical factors, e. g. water supply,

climate, pest and disease susceptibility, and (b) socio-economic factors, e.g. relative prices, input supplies, education and tenure.

Despite the variation in the rate of adoption of MV rices both between countries and among farms, their adoption in combination with other inputs like fertilizer and irrigation has been able to boost production and productivity throughout tropical Asia (ADB 1976).

The Situation in Nepal

Like many other countries, Nepal now faces a land constraint problem and has no alternative but to intensify methods of cultivation, if it is to remain self-sufficient in food production. Although the new seed technology, in particular for rice, has not been as popular in Nepal as in some other countries, its appropriateness should not be under-estimated in a country where 60 per cent of all holdings are farms of 1 hectare or less (ADB 1976).

In Nepal, rice yield per hectare remains below 2 tonnes. This low yield can be attributed mainly to the lack of diffusion of MV rices, associated fertilizer technology and lack of controlled irrigation. The Agricultural Statistics of Nepal (1977) reports that out of a total of 1.2 million hectares of rice land, 17 per cent is under MV rice seeds. The acceptance by farmers throughout the country of the MV wheat seeds (mainly RR 21) has helped increase the total acreage under wheat from 100,000 hectares in 1963/64 to 348,000 hectares in 1976/77. The increase in land planted to wheat is almost exclusively sown to MV wheat.

OBJECTIVES OF THE STUDY

This study focuses on two districts of Nepal, Morang and Sunsari, in an attempt to document and analyse factors that explain the variability in the adoption of MV among farms. This area was chosen for the following reasons:

1. The area is accessible and known to the researcher.
2. It is one of the major cereals growing areas of Nepal.
3. The area is regarded as responsive to the adoption of new agricultural innovations.
4. There is high concentration of agricultural and infrastructural support in the area.

The specific objectives of the study were :

1. to analyse factors contributing to variation in the adoption of MV among farms in the region;
2. to examine factors explaining variability in the amount of chemical fertilizer used at the farm level;

3. to draw inferences from the study as a guide to increase rice and wheat production in the eastern Tarai area of Nepal.

The study enabled the following hypotheses to be tested:

1. Variables like irrigation, education, extension, credit and experience with MV are important determinants of variability in the level of adoption of MV between farms.
2. Cost of fertilizer, education and experience in fertilizer use contribute to the difference in fertilizer use at the farm level.
3. Resource use per hectare in the production of MVs is higher than for LVs.

ANALYTICAL PROCEDURE

IRRI studies on factors influencing the farmer's adoption of modern varieties were mainly focused on cross country comparisons. Their analytical model (Anden and Barker 1973) was:

$$PAM = a + b_1 PR + b_2 S + b_3 T + b_4 P + e$$

Where: PAM = percent of rice growing area of a village planted to MV;

PR = ratio of price of MV to the price of LV;

S = season dummy (S = 1, wet season; S = O, dry season);

T = dummy for type of farming (sole versus multiple cropping);

P = dummy for location (P = 1 for Philippines, O elsewhere);

e = error term.

Since there is little variation in the relative prices of MV and LV and less heterogeneity in the types of farming systems within regions, this type of model is less appropriate for a within-country analysis. Therefore, alternative models were estimated to determine which factors significantly influence the adoption of MV and chemical fertilizer between farms.

The following least squares models were estimated:

$$PMR = a_1 + \sum_{j=1}^{7} b_{1j} X_j + k_1 D + e_1 \quad \ldots\ldots (1)$$

$$PMW = a_2 + \sum_{j=1}^{7} b_{2j} X_j + k_2 D + e_2 \quad \ldots\ldots (2)$$

$$YACF = a_3 + b_{33} X_3 + \sum_{j=7}^{11} b_{3j} X_j + k_3 D + e_3 \quad \ldots\ldots (3)$$

Where: PMR, PMW and YACF are the dependent variables as defined below:

a_i = constant term;

b_{ij} = partial regression coefficients of X_j;

X_j = explanatory variables as defined below:

D = dummy variable which takes a value of 1 in case of institutional borrower of credit, and 0 otherwise;

k_i = coefficient of the dummy D;

e_i = error term;

i = equation number, i=1, 2, 3;

j = variable number, j=1, 2,....11.

Specification of Dependent Variables

PMR is the proportion of land a farmer has planted to modern rice to total land he cultivates, that is:

$$PMR = \frac{\text{Land under MV Rice}}{\text{Total Cultivated Land}} \times 100$$

PMW = is likewise defined for wheat

YACF = Quintals (10^ kg) of inorganic fertilizer used per farm

Specification of Explanatory Variables

Farm specific continuous variables were identified as follows:

X_1 = farm size in hectares;

X_2 = number of adults working full-time on the farm;

X_3 = number of years of formal schooling of the farm operator;

X_4 = proportion of the cultivated land which is irrigated;

X_5 = proportion of low land a farmer has to the total land he cultivates;

X_6 = number of times per year the farm is visited by an extension agent;

X_7 = number of years since the modern variety of rice, wheat and fertilizer, respectively was first used on the farm;

X_8 = cost of fertilizer at farm gate (i.e. including transportation cost);

X_9 = quantity (kg) of farm yard manure (FYM) used;

X_{10} = area (ha) under MV rice;

X_{11} = area (ha) under MV wheat;

D = dummy variable which takes a value of 1 in case the farmer is an institutional borrower of credit, and O otherwise.

To avoid highly correlated variables being included in the model tests were made for multi-collinearity between variables (Wonnacott and Wonnacott 1972). The variables X_1 to X_{11} and D are not correlated to the extent that multi-collinearity would pose a statistical estimation problem.

Sources of Data

The data base for the present study was Morang and Sunsari districts of Kosi zone lying in the Tarai zone of Eastern Nepal, on the northern fringe of the Gangetic plains. Modern varieties of rice were introduced in early 1970s. Improved wheat seeds were first grown in 1963 by farmers in the area.

A field survey was conducted by the author from November 1978 to January 1979. Because the main objective of this study was to pinpoint key factors affecting the adoption of modern varieties of rice and wheat, secondary information on the use of MV, fertilizer, credit and irrigation facilities was first obtained from institutions like branch offices of the Agricultural Development Bank, the Department of Agriculture and cooperatives.

Due to a paucity of recorded information on farming systems and the productivity of rice and wheat, personal interviews were conducted with 181 farmers to obtain information on their ricebased cropping systems.

To ensure that the range of farming systems found in the area were included in the survey, 7 pockets from Morang and Sunsari districts were pre-stratified in relation to:

1. extent of adoption of MV and fertilizers;
2. "location", i. e. distance from a highway;
3. extent of irrigation facilities.

Having identified the sampling cells, 181 farmers were randomly selected for interviews, with at least 20 farmers from each cell.

CHARACTERISTICS OF FARM HOUSEHOLDS AND PRODUCTION SYSTEMS

The land holdings in the area showed a skewed distribution with 57 per cent of the sampled farmers falling within the small size category (below 2.71 ha) (Table 1).

Table 1 : Sample Farmers by Farm Size.

Farm size	Observation	
	Number	%
Small (Below 2.71 ha)	103	57
Medium (2.71 to 6.77 ha)	46	25
Large (Above 6.77 ha)	32	18
Total	181	100

Note: The size categories are based on rates of land tax. The original data was collected in **bigha** (1 **bigha** = 0.677 ha).

Farm size is positively skewed showing that a small proportion of farmers control a disproportionately large proportion of the cultivated land. The modal farm size was 2.5 hectares – only 9 farmers had farms larger than 9 hectares.

The average number of persons in the sample households was between 8 and 9 individuals, with 2 to 3 members of the household working full-time on the farm. Regarding educational attainment of the farm operator, 127 had formal schooling, the average years of formal schooling being 5.3 years.

Rice was clearly the most important crop as far as contribution to farm income is concerned. Jute was ranked second and wheat third. The dominant winter crops are wheat and mustard. Maize, jute and local rice, with a maturing period of 165 days, are often planted before the onset of the monsoon. Modern rices, with a maturing period of 120 days, are planted after the monsoon has commenced.

IR8 is the most widely grown MV rice in the Tarai, but from a taste-preference point of view is considered inferior to LV rice. It is also more susceptible to insects than LV.

The modern varieties of rice were found to be higher yielding than the traditional varieties (Table 2). As traditional wheats are no longer grown, no similar comparison is possible between MV and LV wheats. The mean yields of LV rice (approximately 1.9 Mt/ha) was estimated to be 30 per cent lower than the MV (approximately 2.7 Mt/ha) While total labour requirements are similar for MV and LV rice production, hired labour constitutes a larger proportion of the labour used to grow the MV crops as compared with LV crops (Table 2).

Table 2 : Estimated Gross Yields and Labour Use for MV and LV Rice and Wheat.

	Rice		Wheat
	MV	LV	MV
Gross yield (Mt/ha)	2.7	1.9	1.3
Total labour requirement (days/ha)	175	174	79
Hired labour (days/ha)	124	105	54
Hired labour as % of total labour	71%	61%	68%

The major sources of added plant nutrients used to grow wheat and rice are farm yard manure and inorganic fertilizers (mainly 20-20-0 and urea). Not all farmers use fertilizers, and the quantities of compost and inorganic fertilizer used by farmers were independent ($r = 0.05$). In the case of LV rice, it was uncommon for farmers to apply inorganic fertilizer. The average dose of fertilizers for MV rice and wheat was 0.91 and 1.70 Mt/ha, respectively.

REGRESSION RESULTS

The survey findings reveal that all farmers grow local varieties of rice. Owner-operators often grow both modern and local varieties of rice and wheat, while tenant farmers grow mainly local varieties of rice, with a small proportion of tenants growing modern wheats as well (Table 3).

Table 3. Proportion of Farmers Growing MV and LV Rice and Wheat.

Category	Rice		Wheat a/	
	MV	LV	MV	No Wheat Grown
Owners (n=141)	55	100	71	29
Tenants (n= 40)	5	98	41	59
Total (n=181)	44	99	64	36

Note: a/ No LV wheat is grown by sample farmers.

Factors Influencing the Proportion of Land Planted to Modern Varieties:

Rice

Based on a review of similar adoption studies, a number of factors were identified and included in the present analysis. A simple correlation matrix was generated for all variables. Any two variables with a simple correlation of 0.65 or greater were not included in the same regression model.

The statistically most robust model, which is reported in Table 4, showed that as farm size increased by one hectare, the proportion of the farm land grown to MV rices fell by 1·3 per cent.

The factors found to significantly influence the proportion of land which owner-operators planted to modern rice were :

- farm size;
- proportion of low land to total land;
- proportion of farm irrigated;
- size of the family labour force available for farm work;
- operator's education;
- frequency of visits of extension agent;
- number of years since MV rice was first used;
- farmer's use of institutional credit.

Many rice adoption studies report irrigation to be the "key" variable in farmer's adoption of MV rice. However, as shown by the regression coefficients in Table 4, the level of education of the operator, the number of visits by extension agents and access to formal sources of credit are more important than irrigation. This suggests that in the case of the eastern Tarai, factors related to communicating modern technology to farmers are extremely important.

Wheat

A similar regression model was constructed to examine the variability in the proportion of land planted to MV wheat. On an average, farmers planted nearly a quarter (24%) of their land to MV wheat, compared to 19 per cent of the area grown to MV rice.

As was the case for MV rice, farm size was found to be inversely related to the proportion of the farm grown to MV wheat (Table 4). Factors related to the farmer's awareness of the practice, together with the irrigation variable, were the most significant variables related to proportion of farm planted to wheat. The education of the operator appeared to be a less important factor than in the case of rice.

An examination of Tables 4 and 5 shows that the irrigation factor is more important for wheat than for rice (compare the regression coefficient of 0.06 and 0.04). This is as anticipated: rice is grown in the monsoon season, and wheat in the relatively drier winter season. Consequently, irrigation is more critical for wheat than for rice production.

Chemical Fertilizers

Because modern varieties of rice and wheat are responsive to the application of fertilizers, it is economically attractive at least for the owner-operator to use chemical fertilizers if input and output prices are attractive. The quantity of fertilizers used per farm (in quintals) was regressed against a number of factors regarded as influencing its level of use (Table 5).

The most significant factors influencing the use of fertilizer were the area under MV wheat and rice, respectively. With a one hectare increase in the area of these crops, fertilizer use is predicted to increase by 1.12 and 0.77 quintals, respectively. Farmers with long experience in fertilizer use as opposed to more recent adopters, and operators who used formal sources of credit also used higher levels of fertilizer than those using informal sources of credit for farming. Operators faced with high fertilizer cost used significantly lower levels of fertilizer than those faced with low costs of the input. The main difference in cost between farmers was due to transport costs from the cooperative to the farm. Thus, the fertilizer cost factor acts as a proxy for the location of the farm in relation to the supply of fertilizer.

Table 4 : Factors Affecting Proportion of Land under MV Rice and MV Wheat.

Independent Variables	Regression Coefficients	
	Rice	Wheat
Intercept	- 25.25	4.43
Farm size (ha)	- 1.26*** (4.6)	-1.65*** (5.0)
Proportion of low-land to total land (%)	0.20*** (2.5)	0.03 (0.3)
Number of full-time working adults in the family (persons)	1.13* (1.2)	0.18 (0.9)
Operator's education (years)	2.82*** (4.6)	1.22 (1.6)
Proportion of area irrigated to total land (%)	0.04*** (2.7)	0.06*** (4.4)
Number of years since MV rice or wheat, respectively was first used (years)	1.11** (1.6)	2.6*** (3.3)
Number of visits by extension agents (number)	1.10*** (3.0)	0.23*** (5.3)
Credit dummy	8.32** (1.7)	4.83 (0.8)
Coefficient of determination (R^2)	0.52	0.40
Adjusted $\bar{R}^2$	0.49	0.37
F - Value	22.96***	14.18***

Note : Figures in parentheses are t- values

***, **, *=significant at 1, 5 and 10 per cent level, respectively.

Table 5: Factors Affecting Quantity of Chemical Fertilizer Used at the Farm.

Independent Variables	Regression Coefficient
Intercept	-1.82
Cost of fertilizer (Rs)	-0.18*** (1.5)
Number of years since fertilizer was first used (years)	0.37*** (4.2)
Operator's education (years)	0.20 (0.22)
Quantity of FYM used (kg)	0.38 (3.21)
Area under MV rice (ha)	0.77*** (3.21)
Area under MV wheat (ha)	1.12*** (4.9)
Credit dummy	0.77*** (2.05)
Coefficient of determination (R^2)	0.59
Adjusted ($\bar{R}^2$)	0.57
F - value	31.30***

Note : Figures in parentheses are t-values

***, **, * = significant at 1, 5 and 10 percent, respectively.

SUMMARY AND CONCLUSIONS

The study was designed to identify differences in the level of resource use and productivity between MV and LV of rice and wheat. Linear regression models were used to provide insights to the reasons for the variability of MVs rice and wheat, and chemical fertilizer among farms.

As found in other studies, MV was found to be higher yielding than local rices. The proportion of hired labour to total requirement was significantly higher in MV rice production. This finding allows us to conclude that the introduction of MV, through a substitution of hired labour for family labour, has increased employment of the poorest section of the community, the landless worker and the tenant farmer who work part-time on other farmer's fields. The welfare implications of introducing MV rice and wheat seem to be consistent with government's objective of both increasing productivity and the welfare of rural people.

Factors explaining the variation in the proportion of area planted to MV were the educational status of the farm operator, his exposure to extension, his experience with the practice and irrigation facilities. Factors explaining the variability in the use of chemical fertilizer were the cost of fertilizer, experience with its use, area planted to MVs, farm size and credit.

Inspite of the higher yield performance and profit associated with MV rice, it was found that the proportion of farms planted to MV rice was less than one quarter of farm size. The two important factors for this may be: first, the most ready market (both export and domestic) is for LV as opposed to MV rice; second, as the MV are generally harvested during the monsoon, the trader is faced with the problem of drying this high moisture rice.

Investment in agriculture research should be continued to make modern varieties of rice and wheat more competitive with local varieties in relation to yield and yield stability, and palatibility for human consumption in order to reduce the price differential.

IR 8 is considered inferior taste-wise and is susceptible to insects when compared to LVs. More recently, developed MVs which have more desirable agronomic and market characteristics should be made available to replace IR 8. At the same time, investment in irrigation and education and extension programmes could expand the type of environment in which MV are best adopted. Since these factors appeared significant in explaining the variability in the proportion of area planted to MV, further increase in area planted to MV can be influenced by HMG's policies in relation to future extension of education and irrigation programmes.

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