PN-AAJ-878

HMG-USAID-A/D/C PROJECT
TRAINING NEPALESE IN AGRICULTURAL RESEARCH
AND DEVELOPMENT PLANNING

RESEARCH PAPER SERIES

Number 12 September 1981

The Impact of Modern Varieties of Rice on Farm Income and Income Distribution in Eastern Nepal

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AGRICULTURAL PROJECTS SERVICES CENTRE · NEPAL · 1975

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FOREWORD

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The Ministry of Food and Agriculture appreciates the efforts of Dr Shao-er Ong and Dr. Veit Burger, the A/D/C staff in Nepal, and of Dr Ram Prakash Yadav, the Executive Director of APROSC, in making the publication of this Research Paper Series possible

February 1980

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THE IMPACT OF MODERN VARIETIES OF RICE ON FARM INCOME AND INCOME DISTRIBUTION IN TWO DISTRICTS OF EASTERN TARAI, NEPAL

*Bharat B. Karki**

ABSTRACT

The study aimed to identify the relationship between the adoption of modern varieties of rice (MVs) and farm size and to compare the levels of inputs use and productivities of MVs and traditional varieties (TVs). Differences in the composition of total labor (hired and family) while producing MVs and TVs were also examined in the process of the study. The Constant Elasticity of Substitution (C.E.S.) production function was used to test whether the elasticity of substitution (σ) between labor and capital, which indicates changes in relative factor shares, differed in the two production technologies.

It was found that farm size and adoption of MVs were independent. Though the cost of inputs was higher for MVs than for TVs, a relatively higher yield per hectare from the MVs resulted in a higher net income for the adopters of the new technology. The absolute share of hired labor was higher for the MVs compared with traditionally produced varieties.

The elasticity of substitution (σ) did not differ significantly between the two production technologies. The results imply that the new technology is neither labor nor capital biased, that is, there is no difference in the relative factor shares in the two production processes.

INTRODUCTION

There seems to be general agreement that in irrigated conditions modern varieties of rice (MVs) are higher yielding than traditional varieties of rice (TVs). However, opinions are still divided on some issues such as welfare and employment implications of cultivating MVs. There are some authors (e.g. Falcon 1970, Johnston and Cownie 1969,

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and Wharton 1969), who argue that the introduction of MVs set in process a polarization of rural communities into large commercial farmers and landless peasants. These writers argue that mechanization and adoption of MVs go together and the new technology (inorganic fertilizer and MVs) has a farm size and a labor saving bias, which ultimately results in the declining relative share of labor as compared with capital

However, contrary to their observations, it has also been reported in Asia that farm size did not influence the adoption of MVs and fertilizer use (Barker and Herdt 1977). With regard to employment, the new technology is more labor intensive (ADB/Manila 1977) and the proportion of hired labor in the total labor requirement is higher (Roummasset 1979) when compared with TV practices. Subsidized institutional credit for mechanization, which stems from government policies, is one of the main reasons in accelerating the process of mechanization in Asia (Binswanger 1979).

In the Agricultural Development Plan of Nepal (HMG 1974), it is clearly identified that the main basis for economic development in the country will be through increases in agricultural productivity. The plan further asserts that strategies adopted to increase agricultural productivity will be evaluated on the basis of their contribution to lessening income disparities between regions and among people. In the above context, the government of Nepal has given increased attention to the popularization of modern varieties through professional support prices and extension programs.

Consequently, the area of MV rice in the total rice area is increasing annually as shown in Table 1. Although the proportion of MV rice in the total rice area has not exceeded 23 per cent, the absolute area under MVs is over 200,000 hectares. It draws attention towards some important issues such as:

a) What class of farmers are growing MVs ?
b) Is the profit from MVs higher compared to that from the TVs ?
c) If profit is higher, how is it divided between labor and other factors of production ?

This paper, as such, is an attempt to address these issues.

Table 1: Area under Modern Varieties of Rice, Nepal, 1965-79

(Area: '000 hectares)

Fiscal Year*	Rice		% of MV in total rice area	Total cropped area	% of rice in total cropped area
	MV	Total			
1965/66	6.3	1111	0.6	1995	55.7
1966/67	13.4	1100	1.2	1991	55.2
1967/68	26.1	1154	2.3	2092	55.2
1968/69	43.2	1162	3.7	2137	54.4
1969/70	50.3	1173	4.3	2193	53.5
1970/71	67.9	1182	5.7	2231	53.0
1971/72	81.6	1201	6.8	2265	53.0
1972/73	177.0	1142	15.5	2235	51.1
1973/74	205.0	1227	16.7	2328	52.7
1974/75	222.6	1239	17.9	2264	52.4
1975/76	216.4	1256	17.2	2410	52.1
1976/77	220.3	1262	17.5	2426	52.0
1977/78	290.5	1264	23.0	2481	50.9
1978/79	212.6	1263	16.8	n.a.	-

Source: Agricultural Statistics of Nepal, 1972, 1977.

Notes: MV = Modern Variety

n.a. = Not available

* = The Nepalese fiscal year starts approximately on 16 July.

METHODOLOGY

Morang and Sunsari districts in south Kosi Zone of the Eastern Tarai were selected for this study. Greater accessibility of the region, a higher rate of adoption of MVs and increased mechanization were the main factors considered in the selection of these districts.

To ensure that observations were derived from all types of farms in the sample, the following three criteria were considered as a basis for the selection of sample area:

i) Degree of adoption of MV paddy seeds and fertilizer;
ii) Degree of mechanization; and
iii) Distance from highway/access to the market.

The Panchayats (local level administrative units) which used more of MV paddy seeds and fertilizer than the average ones, were listed among the adopter category of the Panchayats. Any household cultivating a parcel of MV paddy crop (irrespective of the size of the parcel) was considered an adopter.

Farmers adopting MV paddy used more fertilizer and other purchased inputs, and the productivity of these inputs tends to increase in irrigated conditions. For this reason, irrigation pumpsets are becoming an important form of mechanization in the rural area. Accordingly, data on irrigation pumpsets are considered.

During the survey it was found that tractors were used more for transportation and less for land preparation. Thus tractors were not included in the study.

MV rice is harvested in the latter part (September-October) of the wet season. Thus, the quality of grains deteriorates if it is not dried properly and disposed of in the market. Accessibility of the market is, therefore, an important factor determining the adoption of MVs.

Eight sampling strata were identified based on these three criteria (Figure 1).

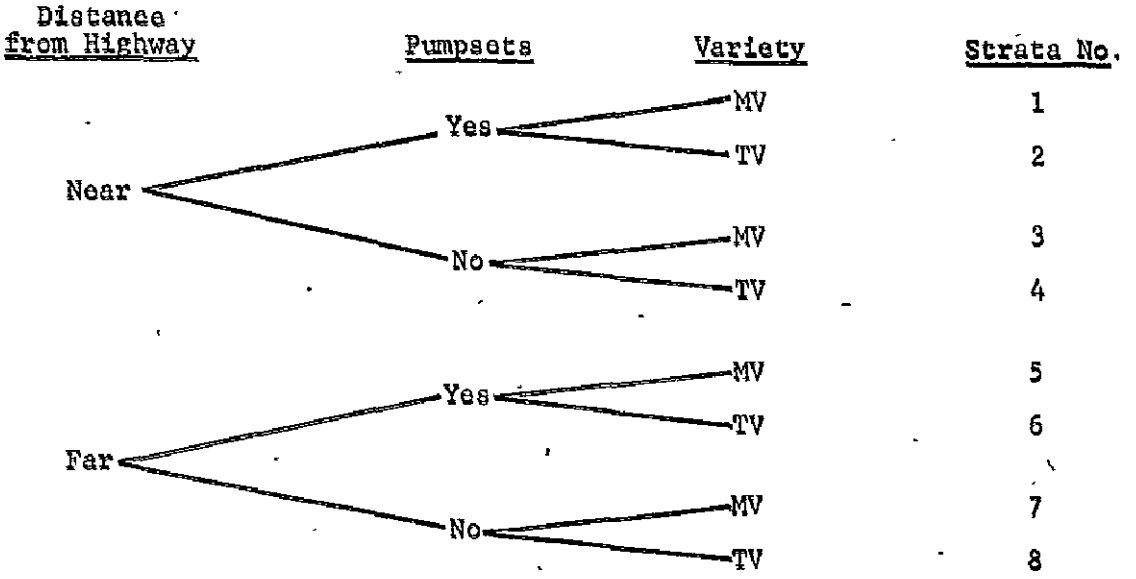

Figure 1. Tree Diagram of Sampling Strata

No observations were found in the seventh stratum as it was difficult to locate a place where MVs were grown and pumpsets were used that was also away from the highways. From the remaining seven strata, a total of 180 farmers were interviewed from October to December, 1978, using a questionnaire prepared by the researcher. The questionnaire included information on farm production, labor requirements, input costs, etc.

RESULTS

General Characteristics of the Sample Farm Household.

The existing cropping pattern in the survey area is very much monsoon dependent and subsistence oriented and a large portion of the cropped area for most of the year is under foodgrains like paddy, wheat and maize. The important cash crops grown are sugarcane, oilseeds and jute. The most common cropping practices are as follows:

Upland

a) Jute and oilseeds

b) Maize and oilseeds

Lowland

a) Early and late paddy

b) Early paddy and wheat

c) Jute and late paddy

d) Maize and paddy

e) Paddy

f) Sugarcane

Many traditional varieties of paddy are found in the survey area while IR8, IR20, Jaya and Masuli are some of the popular varieties of MV paddy adopted in the area.

Formal schooling of the farm operators was found to be 5.2 years on the average (Table 2). The average family size is 8.5 and dependency ratio (number of family members not working on the farm divided by total family members) is 0.5. On the extension scene, the extension agents visited the farms between 4 and 5 times on an average in a

year, while the farmers visits to the extension agents were also 4 and 5 times on the average in a year. The 171 responses on credit showed that 101 farmers borrowed from institutional sources, while 60 borrowed from private sources.

Table 2: General Characteristics of Sample Farmers

Characteristic	Average
Family Size	8.5
Full time on farm (adults)	2.7
Part time on farm (adults)	.6
Off the farm (adults)	1.1
Children under 10 years	3.3
Family members above 60 years	.8
Formal schooling of the operator (years)	5.2
Visits by extension agent (times)	4.3
Farmer's visits to the extension agent (times)	4.4

Source: Field Survey.

Adoption of MV and Income/Expenditure Analysis

Farms were classified on the basis of farm size and adoption (Table 3). Three categories of holdings were identified namely small (equal to or less than 2.71 ha), medium (2.71 to 6.77 ha) and large (greater than 6.77 ha). The initial unit of measurement of land was the "bigha", which is equivalent to about 0.67 ha.

Table 3: Sample Farms Classified by Farm Size and Adoption of Modern Varieties

Farm Size		Number of farms growing					
		TV		MV		Total	
		No.	%	No.	%	No.	%
Small	(≤ 2.71 ha)	36	42	50	58	86	100
Medium	(2.71 to 6.77 ha)	24	39	38	61	62	100
Large	(≥ 6.77 ha)	19	59	13	41	32	100
Total		79	44	101	56	180	100

Source: Field Survey.

Note: Computed Chi-square value 3.95 with 2 d.f. is less than tabulated value of 5.99, and therefore is not statistically significant at the 5% level of confidence.

TV = traditional variety

MV = modern variety

A Chi-square test indicated that farm size and the adoption of MVs are not related, i.e., in the survey area larger farms are not more likely to adopt MVs than smaller farms. On the contrary, the proportion of small farms having adopted MVs is higher (58%) than that of large farms (41%) but this difference is statistically not significant. Hence it is concluded that farm size and adoption of MVs are independent of each other.

An income and expenditure statement per hectare of MV and TV rice was prepared. On the income side, the value of paddy produced per hectare was computed. The expenditure side includes three cost components namely: capital; intermediate inputs; and labor. Capital cost comprises tractor cost, bullock power cost, irrigation pump cost, land rent and land tax. Cost of seeds, fertilizer, farm yard manure and herbicides were treated as intermediate input costs. Labor cost consisted of hired as well as family and exchange labor costs. Family owned resources were valued at the market prices Purchase and sales prices were used for other purchased inputs and output sold in the market.

The statement on cost of production and income is presented in Table 4. The yield per hectare of the MVs is 42 per cent higher than that of the TVs and the difference is statistically significant. Further, it was found that the expenses incurred for inputs like irrigation, tractors, fertilizer, etc., are higher for MVs than for TVs.

Land rent and tax was attributed to all crops grown in the parcel of land in the survey year. The cropping intensity of the parcels in which MV paddy was cultivated was higher than in the TV cultivated parcels, which resulted in a lower land cost for MV paddy. Farmers cultivating MVs used more fertilizer and irrigation water, which raised their costs for growing MVs. Consequently, the cost of production of MVs are 56 per cent higher than for TVs. But, the yield advantage more than offsets the higher cost of production for MVs and thus has resulted in a 22 per cent higher net income per hectare for the adopters of the new technology.

The average yields of TV paddy from 1973/74 to 1978/79 for the Tarai and Nepal were equivalent to 1820 kg and 1920 kg per hectare, respectively (HMG 1978). The yield estimated from the survey data is 1888 kg for TVs and 2708 kg per hectare for MV paddy. The price of MV paddy is Rs 1.19 as compared to Rs 1.23 per kg of TV. Since MVs are harvested during the wet season, farmers were selling MVs at a

Table 4: Costs of Production and Income per Hectare of Traditional and Modern Varieties of Rice (Rupees)

	Variety	
	Traditional	Modern
Capital Cost (Rs)	363*	570*
Land rent and tax	100	80
Bullock Power	234	240
Irrigation	12	62
Tractor	17	188
Intermediate Inputs (Rs)	159***	392***
Seeds	126	136
Farm yard manure	28	101
Fertilizer	4	155
Labor cost (Rs)	621***	837***
Total cost (Rs)	1,142***	1,799***
Yield (kg/ha)	1,888***	2,708***
Price (Rs/t)	1,230	1,190
Gross Income (Rs)	2,322	3,223
Net Income (Rs)	1,180	1,424
Sample size	79	101

Source: Field Survey.

Note: t-tests were only performed for the major cost components.

*** = Significant at 1% level
** = Significant at 5% level
* = Significant at 10% level

Exchange rate 1 US$ = 12 Nepalese Rupees (Rs) at the time of the field survey.

slightly lower price compared to TVs because the moisture content of MV paddy is above the normally acceptable level of 15 per cent.

Family and Hired Labor Composition in the Total Labor Requirements

Labor is defined as total adult man-days engaged on the farm. A distinction was made between hired and family labor while entering the responses of farmers into the questionnaire. Family labor also includes exchange labor. Comparative figures of labor usage in different farming operations are presented in Table 5 for MVs and TVs.

From Table 5 it can be seen that MVs require substantially (26%) more labor than TVs (i.e. 135 days vs. 107 days per hectare). Most of this additional labor, however, is required in pre-harvest and harvest operations, while labor use in land preparation and crop establishment is roughly equal for MVs and TVs. Comparing family with hired labor one finds that hired labor is used in much higher proportions in MVs (78%) compared with TVs (56%), even to the extent that total family labor declines absolutely from 47 days to 29 days per hectare when one shifts from TVs to MVs, while hired labor increases from 60 to 106 days. Only in the pre-harvesting operation does family labor not decline absolutely; there, it increases slightly from 3.6 days to 5

Table 5: Labor Inputs per Hectare (in man-days) for Traditional and Modern Varieties of Rice

Task and Labor Source	Variety			
	Traditional	%	Modern	%
Land preparation				
Family and exchange	19.9***	59	12.9***	37
Hired	13.6***	41	22.0***	63
Total	33.5	100	34.9	100
Crop establishment				
Family and exchange	10.7**	45	5.3**	20
Hired	13.3***	55	21.6***	80
Total	24.0	100	26.9	100
Pre-harvest				
Family and exchange	3.6	37	5.0	23
Hired	6.2***	63	16.4***	77
Total	9.8***	100	21.4***	100
Harvest				
Family and exchange	12.9***	32	6.2***	12
Hired	26.9**	68	45.6***	88
Total	39.8*	100	51.8*	100
TOTAL				
Family and exchange[a/]	47.1	32	29.4	12
Hired[a/]	60.1	68	105.6	88
Total	107.1**	100	135.0**	100
Sample size	79		101	

Source: Field Survey.

Note: a/ t - test not used
*** = Significant at 1% level
** = Significant at 5% level
* = Significant at 10% level

days per hectare. The reason for this increase in family labor is that modern varieties require more careful weeding and that the required timeliness of weeding and its spread throughout the crop-growing period favor the use of family labor.

The gross income from cultivating MVs in a hectare of land was Rs 3,223 as against Rs 2,322 for TVs (see Table 4). With the increase in the gross income from MVs the marginal utility of not engaging in hard labor increases relative to the marginal utility of additional income which has led to the substitution of family labor by hired labor in producing MVs (Roumasset 1979).

Labor's share is defined as the wage rate multiplied by the quantity of labor used. Table 6 provides a comparison on how the share of hired and family labor differed between MVs and TVs. As previously mentioned, although the use of family labor is lower for MVs, total labor use is 26 per cent higher than that for TVs. Further, the use of hired labor was 76 per cent higher for MVs compared with TVs. The wage rate is slightly higher for MVs. The difference can be attributed to the inter-village differences in wage rates. The total labor and hired labor share is 34 and 88 per cent higher respectively in the cultivation of MVs compared to TVs.

Table 6: Comparison of Labor Use (mandays and earnings) for Traditional and Modern Varieties of Rice

Labor Source and Cost	Variety	
	Traditional	Modern
Family and exchange labor (man-days/ha)	47.1 (100) a/	29.4 (63)
Hired labor (man-days/ha)	60.0 (100)	105.6 (176)
Total labor (man-days/ha)	107.1 (100)	135.0 (126)
Wage rate (Rs/man-day)	5.8	6.2
Hired labor cost (Rs/ha)	348 (100)	655 (188)
Total labor cost (Rs/ha)	621 (100)	837 (134)

Source: Field Survey.

Note: a/ Figures in parentheses are indices with traditional varieties as base.

Distribution of Benefits from MV Cultivation between Laborers and Capital Owners

Increased use of labor while cultivating MV rice does not necessarily improve the lot of laborers relative to capital owning classes unless the wage rates are adjusted upwards sufficiently to offset the effect of increase in the return to capital. The elasticity of substitution (σ) between labor and capital provides a precise measure of the change in the factor proportions and their returns in any production technology. This parameter is defined as proportionate change in factor ratio divided by proportionate change in price ratio of the inputs (Robinson 1973). Given a production function:

$$Y = f\ (L,K)$$

where: L = Labor
K = Capital

the elasticity of substitution is defined as

$$\sigma = \frac{du/u}{dr/r}$$

where: u = L/K, the Labor Capital ratio
r = q/w, the factor price ratio.

Unfortunately, in the Cobb-Douglas production function σ is equivalent to unity. Hence, to estimate the value of σ in two different technologies, namely, traditional and modern, a Constant Elasticity of Substitution (C.E.S.) production function (Arrow et al, 1961) was employed and is given by:

$$Q = \gamma\ [\delta K^{-\rho} + (1-\delta)\ L^{-\rho}]^{-1/\rho} \qquad (1)$$

Where: Q = value added in output in monetary units (Rs/ha)
γ = technological or efficiency parameter
δ = distribution parameter between labor and capital
K = Capital, measured as the value of capital services in monetary units
L = Labor, measured as the amount of total labor in mandays
ρ = Substitution parameter between labor and capital, where the elasticity of substitution (σ) is defined as

$$\sigma = \frac{1}{1 + \rho} \qquad (2)$$

(If $\rho = 0$; this function reduces to the Cobb-Douglas Production Function).

The above relation (2) can be estimated directly in loglinear form using the maximum likelihood method, although this is difficult. To overcome this difficulty an indirect method of estimation is commonly used (Brown 1968). Assuming perfect competition in both factor and product markets the estimating equation is given by:

$$\log (L/K) = \sigma \log \left(\frac{1 + \delta}{\delta}\right) + \sigma \log (q/w) \qquad (3).$$

To test the equality of σ between traditional and new technologies, equation (3) is estimated by using a dummy variable, and an F-test (Rao and Miller 1972, Johnston 1972) is employed to test whether σ between the MVs and TVs is significantly different. Thus the equation to be estimated is:

$$y = \alpha_o + \alpha_1 D + \alpha_2 x + \alpha_3 (xD)$$

Where: $y = \log (L/K)$

$\alpha_o = \sigma \log \left(\frac{1 + \delta}{\delta}\right)$

α_1 = Estimated regression coefficient of dummy D (for intercept)

α_2 = Estimated regression Coefficient of x, which is equivalent to σ of equation (3)

$x = \log (q/w)$

α_3 = Estimated regression Coefficient for dummy D (for slope of estimated line)

D = 1 if TV

= 0 if MV

For the estimation, the data were standardized in per hectare units for all farms.

It should be recognized that in the survey it was impossible to collect information on the quality of land. The exclusion of this variable together with the assumption that hired and family labor are perfect substitutes are two factors, which contributed a somewhat low value of $\bar{R}^2$ (Table 7).

Equation I refers to estimation when a slope dummy is included while equation II refers to estimation when the slope dummy is excluded. The F-ratio for both regressions is highly significant.

If the prices of inputs change, the firm will substitute the relatively cheaper input for the more expensive one. This profit-

Table 7: Regression Parameters to Test the Change in Elasticity of Substitution (σ)

Estimated Parameter	Variable	Dependent variable: log (L/K) Regression	
		I	II
a_o	intercept	-.438	-.447
a_1	intercept dummy	-.033	-.014
a_2	elasticity of substitution	.371*** (.051)	.296*** (.034)
a_3	slope dummy	-.132** (.069)	-
$\bar{R}^2$		.298	.287
No. of observations		180	180
Residual sum of squares (RSS)		6.75	6.89
F - ratio		26.50***	37.37***

Note: (Figures in parentheses indicate standard errors)
*** = Significant at 1% level
** = Significant at 5% level
* = Significant at 10% level

maximizing behavior will result in a change of the L/K ratio, and hence, in a change in the relative shares of the factors. The size of this effect depends on the responsiveness of the change of the L/K ratio to the factor price changes. A measure of this responsiveness is the elasticity of substitution (Koutsoyiannis 1979). The estimated value of elasticity of substitution (σ) under equation 2, is equal to about 0.3, which indicates that a 10 per cent increase in the factor price ratio results in a 3 per cent increase in the L/K ratio. The responsiveness of the change in the L/K ratio with respect to the factor price changes has increased in equation 1 relative to equation 2 as indicated by the higher estimated value of σ.

It was revealed that 50 and 57 mandays of labor were used in producing one metric ton of MV and TV rice, respectively, whereas the capital cost per metric ton of MV and TV rice was Rs 210 and Rs 192, respectively. The farmers used slightly higher amounts of capital costs and less man-days of labor per metric ton of MV rice produced compared with the TVs.

An F-test, however, showed that the elasticities of substitution between labor and capital (σ) in the two production technologies do not differ significantly. This suggests that MV rice production technology is neutral (i.e. neither capital nor labor biased) compared to the traditional technology.

SUMMARY AND CONCLUSIONS

The adoption of modern varieties of rice in the study area was not dependent on farm size.

It was found that higher levels of expenditure were incurred in inputs like irrigation, tractors, fertilizer, etc. while cultivating modern varieties as compared with traditional varieties. But the yield advantage is more than the cost burden for modern varieties, resulting in a 22 per cent higher net income for adopters of the new technology.

The total labor used per hectare in MV cultivated areas was 26 per cent higher than in TV cultivated areas. Most of this additional labor, however, is required in pre-harvest and harvest operations, while labor use in land preparation and crop establishment is roughly equal for modern and traditional varieties. Comparing family labor with hired labor one finds that hired labor is used in a much higher proportion of total labor in modern varieties (78%) compared with traditional varieties (56%).

Labor use with greater intensity when cultivating modern varieties does not necessarily improve the lot of laborers relative to the capital owners unless wage rates are adjusted upwards sufficiently to offset the effect of increase in return to capital. The elasticity of substitution (σ) between labor and capital provides a precise measure of the changes in the factor proportions and their returns in any production technology. Hence, to estimate the value of σ in two different technologies namely traditional and modern, a Constant Elasticity of Substitution (C.E.S.) production function was employed. Though the farmers used slightly higher amounts of capital costs and less man-days of labor per metric ton of MV rice produced compared with TV rice produced, it was found that the elasticity of substitution estimated for the two technologies do not differ significantly. This implies that the production technology of modern varieties of rice is neutral, which indicates that it is neither labor nor capital biased compared to the traditional technology.

Policy Implications

The production technology associated with the cultivation of

modern varieties of rice is characterized to be neither labor saving nor capital saving compared with that of traditional varieties. Since the yields obtained from the modern varieties were statistically higher compared to those of traditional varieties, the findings suggest that the goals of increasing agricultural production through the adoption of modern varieties, and its equitable distribution among various resources-owning classes, are attainable and compatible. It must be noted, however, that the main forms of mechanization so far adopted in Nepal comprise the limited use of tractors to prepare land, and pump-sets to irrigate land. Introduction of other forms of machines and increased mechanization may, however, change the situation drastically. Our findings, therefore, should be seen in this light.

Only a few tenants were observed producing modern varieties, which raises an important question: "Is the income gap between tenants and owner-operators widening as a result of the adoption of the new technology by owner-operators ?" With the data of this study this question cannot be answered unequivocally, because the demand for the services of tenants, as laborers on owner-operated farms, has increased through the introduction of modern varieties.

The main reason why tenants do not adopt modern varieties as much as owner-operators is the following: Whereas the Land Reform Act of 1964 stipulates that the tenant should pay the land-owner an absolutely fixed rent per hectare (depending on the quality of land), under present cultural practices the production is shared on a proportional basis (generally 50:50, after deduction of harvesting costs). Thus the increased cost of growing modern varieties is borne entirely by the tenant, whereas the increased production is equally shared by tenant and land-owner. If the Land Reform Act were effectively implemented one could expect tenants to adopt modern varieties in much larger proportions.

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Suggested citation: Karki, Bharat B., "The Impact of Modern Varieties of Rice on Farm Income and Income Distribution in Eastern Nepal", HMG–USAID–A/D/C Project on Training Nepalese in Agricultural Research and Development Planning, Research Paper Series No. 12, Kathmandu: The Agricultural Development Council, Inc., September 1981.

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