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HUMAN CAPITAL AND ADOPTION OF INNOVATIONS IN AGRICULTURAL PRODUCTION: INDIAN EVIDENCE

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Abstract

This paper examines the impact of farmers' education and extension contacts on the adoption of High Yielding Varieties (HYV) in single crop (paddy) and multi crop production using a dichotomous logit model. The empirical results based on farm level data from one Indian state, namely Tamil Nadu, demonstrate that education of the farm head and extension contacts have strong positive effects on the probability of adoption of HYV and its intensity of use. The influence of other explanatory variables such as price of variable inputs and quantity of fixed inputs confirm the apriori expectations. The results provide a case for increased spending on rural education and intensifying extension services.

1. INTRODUCTION

Agricultural sector is an important one in India, absorbing, as it does, about 70 percent of the labour force; contributing to about 50 percent of the country's national income, besides feeding the teaming millions and performing the role of supplier of raw materials to the agro based industries. The development of Indian economy is intimately related to the development of the agricultural sector which in turn depends on research and development in agriculture. Creation and introduction of superior inputs into agriculture is the prime mover of development and modernisation. During the pre-green revolution period, agricultural production and productivity in India was low, yet the allocation of resources was efficient (Schultz, 1964). Introduction of new, modern inputs in the form of "Green Revolution" during the mid 1960s has resulted in spectacular changes in agricultural production and productivity.

The progress in the usage of modern inputs and changes in productivity in Indian agriculture during the green revolution phase, 1965-66 to 1984-85 are given in Table 1. The growth in the irrigated area to gross cropped area is very slow, about half percent per annum which is due to constraints in creating additional irrigational infrastructure facilities. However, significant change is observed in the use of fertilizer and High Yielding Variety (HYV) seeds of paddy and wheat. Although the consumption of fertilizer has increased from 7.6 million tonnes in 1965-66 to 82.1 million tonnes in 1984-85, the trend is highly fluctuating due to its supply which depends upon Government's pricing, distribution and import policies, world

TABLE 1

PROGRESS AND USE OF NEW INPUTS AND PRODUCTIVITY IN INDIAN AGRICULTURE DURING GREEN REVOLUTION PERIOD, 1965-66 TO 1984-85

Year	Percentage area irrigated to gross cropped area	Fertilizer consumption		Percentage area under HYV		Yield per Hectar (in Kgs)	
		Total (in million tonnes)	Percentage annual change	Paddy	Wheat	Paddy	Wheat
1965-66	19.9	7.6	-	2.5[a]	4.2[a]	874	838
1970-71	23.1	22.6	28.5	14.9	36.2	1123	1307
1975-76	25.3	28.9	6.0	32.3	65.8	1235	1410
1980-81	28.8	55.2	15.6	45.4	72.3	1336	1630
1984-85	30.5[b]	82.1	9.6	56.9	82.9	1425	1873

Notes : a. figures refer for the year 1966-67
b. figure refers for the year 1983-84.

Sources: 1. Indian Agriculture in Brief (various years), Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India.

2. Fertilizer Association of India (various years), Government of India.

energy crisis, domestric production etc., and demand factors like rainfall, availability of credit etc., However, a continuous progress in the use of HYV in two major Indian crops - wheat and paddy - has taken place during this period. This has resulted in considerable increase in productivity per hectare, as evident from the last column of the table, and thereby food production.

The spread of HYV of wheat, compared to paddy, has been rapid and attained a highest level of 83 percent of the area under wheat in 1984-85. However, HYV of paddy comprises only 57 percent of the area under paddy cultivation. This provides a case for exploring the factors which constrain the spread of HYV of paddy and suggesting appropriate policy measures to remeady the situation.

Schultz (1964, 1975) and Nelson and Phelps (1966) hypothesis that education speeds the process of technological diffusion. That is, farmers with relatively high level of education tend to adopt productive innovations earlier than the farmers with relatively little education. According to them, education increases the farmer's ability to understand and evaluate the information of new processes efficiently and speeds the rate of adjustment to attain equilibrium.[1] Hence, the pay off from innovation will be better and the risk will be smaller for the educated farmers. Empirical evidence from the studies by Rogers' (1962), Wozniak (1984) and Rahm and Huffman (1984) for U.S.A and also from studies by Jamison and Lau (1982), Jamison and Moock (1984), Nerlove (1985) for developing countries lend support to their view. Earlier study by Evenson (1973) bear evidence to the fact that human capital, particularly formal and nonformal (extension) education, play an important role in the adoption of new techniques in developing agriculture. This suggests that farmer's education and extension contacts may be an important factor in the adoption of HYV seeds in the Indian context also which needs to be explored.

The relationship between farmers' level of education and use of HYV in single crop and multicrop production is given in Table 2. The percentage of farms using HYV increases with increase in the level of education of the farm operator and also the percentage area under HYV increases with level of education.

A number of other factors such as availability of irrigation, labour and credit facilities, land tenure system, farmers' attitude towards risk and uncertanity etc., are also responsible for the rate of adoption of HYV in developing countries (Feder, Just and Zilberman, 1985). However, incorporating all these issues in a study will be very difficult. Hence the focus of this study is on the impact of human capital, particularly formal and nonformal (extension) education on the adoption of HYV in agricultural production.

Among the existing studies for India, only Chaudhri (1979) and Rosenzweig (1981) explicitly consider the effect of education on adoption decision. Chaudhri's study uses aggregate district level data for the wheat belt of Punjab and Haryana to test the effect of education on the adoption of HYV seeds. Adoption decision is made at the individual farm level and so analysing the adoption behaviour using farm level data will be

TABLE 2

EDUCATION AND USE OF HIGH YIELDING VARIETIES IN SINGLE CROP (PADDY) AND MULTICROP PRODUCTION, TAMIL NADU, INDIA, 1980-81.

Years of education of head	Percentage of farms using HYV		Percentage area under HYV in multicrop
	single crop	Multicrop	
Less 4	64.60	47.62	54.87
5 - 8	70.08	71.51	65.36
9 - 11	75.51	76.81	70.41
Above 11	100.00	88.89	79.88
All	72.14	65.29	63.33

Source : Sample survey

more revealing. Although Rosenzweig uses farm level data, it refers to the early phase of green revolution (1970-71). In this paper, an attempt has been made to examine the role of human capital, in addition to other economic factors, on the decision to adopt and the intensity of use of HYV of seeds by the South Indian farmers using farm level data for 1980-81.

This paper proceeds as follows : In section 2, a microeconomic model of farmer's adoption behaviour is presented. Section 3, provides the data and empirical specification of the model. In Section 4, empirical results of the dichotomous logit model are presented and discussed. The extent and intensity of use of HYV is examined in section 5. Lastly, in Section 6, the conclusion and policy measures are discussed.

2. A MICROECONOMIC MODEL OF ADOPTION DECISION[2]

The farm household's decision to use HYV over traditional varieties of seed, depends upon the net benefit accruing by its use. We assume that the net benefit associated with each choice is a linear function of a set of independent variables (Z) namely the economic factors (prices of inputs and output, quantities of fixed inputs), location and the farm household's human capital characteristics (education, extension contacts, age etc.,) and an additive random error term e.

The net benefit accruing to the ith farm household by the use of traditional varieties (U_{iT}) and HYV (U_{iN}) is defined as

$$U_{iT} = Z_i \beta_T + e_{iT} \qquad (1)$$

$$U_{iN} = Z_i \beta_N + e_{iN} \qquad (2)$$

Farm household is assumed to choose the technology that gives them the largest net benefit. Defining the adoption indicator variable of the ith farm as Y_i which takes the value of

$$Y_i = \begin{cases} 1 & \text{if} \quad U_{iN} > U_{iT}, \text{ HYV is adopted} \\ 0 & \text{if} \quad U_{iN} \not\leq U_{iT}, \text{ Old variety is used} \end{cases} \tag{3}$$

The probability of using HYV by the ith farm household (P_i) is given by

$$\begin{aligned} P_i &= P_r\,(Y_i=1) = P_r\,(U_{iN} > U_{iT}) \\ &= P_r\,[(Z_i\,(\beta_N - \beta_T) > (e_{iT} - e_{iN})] \\ &= P_r\,(e_i^* < Z_i\alpha\,) = F(Z_i\alpha\,) \end{aligned} \tag{4}$$

where $P_r(.)$ is the probability function, $e^* = e_{iT} - e_{iN}$, is the random disturbance term and $\alpha = (\beta_N - \beta_T)$ is unknown parameter vector and $F(Z_i\alpha)$ is the cumulative distribution function. Thus the probability of the ith farm adopting the HYV seeds is the value of the cumulative distribution function of F evaluated at $Z_i\alpha$. The exact distribution of F depends upon the population distribution of the random disturbance term e_i^* which is unknown. The resulting model depends upon the distributional assumptions of the stochastic disturbance term e_i^*. If one assumes that e_i^* is normally distributed, then this gives rise to a Probit model, on the otherhand, if the distribution of e_i^* is assumed to be logistic, then this leads to a Logit Model. In this study we adopt the latter model. Thus the probability of adoption of HYV of seeds is given by

$$P_i = 1 \,/\, [1+\exp\,(-Z_i\,\alpha\,)] \tag{5}$$

The parameters of equation (5) can be estimated using the Maximum Likelihood technique which yields consistent and asymptotically efficient estimates.

3. THE DATA AND EMPIRICAL MODEL

The data used in this study is drawn from a primary survey conducted by the author in 1980-81 in the paddy dominant region of South-India-Tamil Nadu for the specific purpose of this study. The 24 development districts of Tamil Nadu were stratrified into 2 groups and one district was randomly selected from each of them. Three taluks from each district and 2 villages per taluk were then chosen by simple random procedure. From the selected villages, a list of households was prepared and a random sample of 10 percent of these households was taken. The survey, thus covered 461 individual farm households spread over 12 villages in 2 development districts of Tamil Nadu. Detailed information pertaining to prices and quantities of inputs, and outputs, education, extension contact etc., was collected for all the crops cultivated during the year 1980-81. The details of the sampling method, questionnaire etc., are given in Duraisamy (1984). The main crop cultivated in this area during rainy season is paddy and about 70 percent of the farmers in the sample have cultivated it.

In addition to considering the adoption decision in paddy cultivation we also examine the adoption behaviour taking all crops into account. These two sets of the sample, we denote as single crop paddy production and multicrop production.

The dependent variable (P_i) is defined as adoption dichotomous, taking on the value of one if HYV are used and zero otherwise. Some farmers have used both HYV and traditional varieties of seed in single crop as well as multicrop production.

In this case, he is treated as the user of HYV if he has used HYV in major areas or crops of his production. The independent variables are price of output, price of inputs, quantities of fixed inputs and human capital variables such as education, extention contact and age.

The estimating equation of (5) determining the adoption of High yielding varieties of seed ($DHYV_i$) is

$$DHYV_i = F(\beta_0 + \beta_1 \ln P_i + \beta_2 \ln Q_i + \beta_3 H_i + \beta_4 R_i) \quad (6)$$

where P_i is a vector of prices such as price of output (P_0), wage rate (P_1), fertilizer price (P_f) and price of animal input (P_b), Q_i is a vector of fixed inputs like the value of capital service (Q_k) and net cropped area of land (Q_T), H_i is a vector of human capital variables, namely, education (E), extension contact (EX), and age (AGE), R is a set of other variables represents credit availability and location of the farm and β_i's are parameter vectors to be estimated. The definition of variables and their means and standard deviations are given in Table 3.

Higher the price of output, higher will be the net benefit while an increase in the price of inputs namely labour, fertilizer and animal will decrease the net benefit by increasing the cost of production. So the price of output may be expected to have positive effect, whereas the price of variable inputs - labour, fertilizer and animal input - could have a negative effect on the probability of adoption of HYV. Land area and capital service are fixed inputs, indicating the asset position of the household and a higher level of assets imply greater ability and willingness to take risk and so would be expected to

TABLE - 3

VARIABLE DEFINITIONS, MEANS AND STANDARD DEVIATIONS - SINGLE CROP AND MULTICROP PRODUCTION, TAMIL NADU, INDIA, 1980-81

Variable	Definition	Single crop Mean (Std)	Multicrop Mean (Std)
DHYV	Adoption dichotomous = 1 if High Yielding varieties of seeds are used, o otherwise	0.721 (0.449)	0.653 (0.476)
AHYV	Percentage of net cropped area under High Yielding varieties	69.127 (36.342)	63.328 (31.380)
P_o	Price of Output (Rupees per Kilogram)	1.670 (0.210)	
P_e	Labour wage rate per day (in Rupees)	6.889 (2.312)	7.635 (3.099)
P_f	Fertilizer price (Rupees per Kilogram)	1.920 (0.670)	1.845 (0.748)
P_b	Price of animal input (Bullock labour) per day (in Rupees)	15.754 (6.246)	14.042 (5.561)
Q_k	Value of capital services (in Rupees)	356.38 (372.620)	1809.440 (2932.230)
Q_T	Land area cultivated (in acres)	4.140 (4.210)	13.690 (16.040)
R	Region dummy variable = 1 if East Coimbatore, otherwise 0.	0.573 (0.495)	0.495 (0.501)
E	Education of the Head of the household (in years)	5.76 (4.68)	5.792 (4.446)
ED1	Education dummy = 1 if E < 4, otherwise 0.	0.350 (0.478)	0.364 (0.482)
ED2	Education dummy = if 4 $\leq$ E $\leq$ 8, otherwise 0.	0.393 (0.489)	0.388 (0.488)
ED3	Education dummy = 1 if 9 $\leq$ E $\leq$ 11, otherwise 0.	0.152 (0.359)	0.150 (0.357)
ED4	Education dummy = 1 if E > 11, otherwise 0.	0.105 (0.307)	0.098 (0.297)
ED5	Education dummy = 1 if E $\geq$ 4, otherwise 0.	0.650 (0.477)	0.636 (0.482)
AE	Average education level of other household members (in years)	4.810 (3.84)	3.306 (4.539)
EX	Extension contact (number of times)	6.74 (9.25)	30.824 (44.425)
EXD	Extension dummy = 1 if EX > 0, otherwise 0.	0.653 (0.477)	0.677 (0.468)
CR	Credit dummy = 1 if credit facility used, otherwise 0	0.706 (0.456)	0.971 (0.168)
AGE	Age of the head of the household	41.59 (8.94)	41.063 (7.604)
N	Number of farms	323	461

exert a positive effect on adoption. The education and extension variables should affect adoption decision positively if positive education-adoption hypotheses is true. Age of the head reflects his farm experience and so it should be positive. Use of HYV requires more modern inputs which increases the financial requirements and so credit dummy variable should have a positive effect on the probability of adoption.

3. EMPIRICAL RESULTS

The Maximum likelihood logit coefficient estimates of adoption of High Yielding Varieties of paddy seeds in single crop production, corresponding to alternative specifications and measurement of education and extension variables are provided in Table 4.

From an observation of the results we find that the price of output has the expected positive effect, though not statistically significant at 5 percent level. The labour wage affects the probability of adoption positively, contrary to our expectation. The positive wage rate effect may be the result of the labour using nature of HYV and also large scale participation of farm operators in the labour market. This phenomenon is not explicitily analysed in our study, but Rosenzweig's (1981) earlier finding supports this result. The price of fertilizer and animal input have the expected negative effect on the probability of adoption. Both the variables are not statistically significant at 5 per cent level. Since fertilizer input is sold at uniform prices in all villages through the cooperative stores, there is very little variation in fertiliser

TABLE 4

MAXIMUM LIKELIHOOD LOGIT COEFFICIENT ESTIMATES

ADOPTION OF HIGH YIELDING VARIETIES OF PADDY IN SINGLE CROP PADDY PRODUCTION, TAMIL NADU, INDIA, 1981.

Dependent variable : Adoption of High Yielding Varieties of paddy-dichotomous

	Independent variables	1	2	3	4	5
	Constant	-3.262 (1.615)	-3.154 (1.491)	-3.117 (1.483)	-3.155 (1.453)	-1.022 (0.453)
P_0	Price of output (ln)	2.133 (1.216)	2.437 (1.300)	2.068 (1.138)	2.881 (1.482)	2.229 (1.180)
P_1	Labour wage (ln)	0.723 (1.470)	0.590 (1.147)	0.646 (1.266)	0.666 (1.261)	0.595 (1.141)
P_f	Fertilizer price (ln)	-0.250 (0.655)	-0.534 (1.333)	-0.603 (1.484)	-0.666 (1.603)	-0.486 (1.198)
P_a	Price of animal input (ln)	-0.367 (0.853)	-0.300 (0.678)	-0.340 (0.768)	-0.281 (0.611)	-0.232 (0.516)
Q_k	Capital (ln)	0.396 (1.375)	0.268 (0.919)	0.287 (0.964)	0.169 (0.561)	0.167 (0.558)
Q_T	Land area (ln)	-0.367 (1.166)	-0.697 (2.103)	-0.553 (1.648)	-0.501 (1.477)	-0.617 (1.840)
R	Region dummy	2.420 (4.291)	2.366 (3.941)	2.500 (4.235)	2.710 (4.327)	2.336 (3.839)
E	Education of head (yrs)		0.073 (1.941)			
AE	Average education (yrs)					0.060 (1.279)
ED2	Education dummy ($4 \leq E \leq 8$)				-0.046 (0.135)	
ED3	Education dummy ($9 \leq E \leq 11$)				0.266 (0.578)	
ED4	Education dummy ($E > 11$)				1.270 (3.068)	
ED5	Education dummy ($E \geq 4$)			0.256 (0.805)		
EX	Extension contact		0.157 (3.359)			0.162 (3.426)
EXD	Extension dummy ($EX > 0$)			1.224 (3.647)	1.082 (3.101)	
AGE	Age of head (yrs)					-0.041 (2.333)
CR	Credit dummy					0.111 (0.327)
	-2 log L	157.1	141.090	148.57	138.12	138.72

Asymptotic "t" statistics in parentheses price and this may be the reason for the insignificant effect of this variable.

The coefficient of capital variable has a positive sign, as expected, implying that the HYV technology requires more capital and so increase in capital will increase the probability of adoption of HYV. But the coefficient is not statistically significant at 10 percent level. The variable net cropped area of land has a negative effect, contrary to our expectation, and also significant at 10 percent level in specifications of column 2,3 and 5. This may be due to the short run problem of getting more labour and so they are more willing to use HYV. The region dummy variable is positive and also significant at 5 percent level, which takes account of the regional variation in soil, climate and availability of water resource among the regions.

The years of education of the head of the household has a positive and statistically significant effect at 10 percent level. This confirms the positive education-adoption hypothesis. The education of head dummy variable (in column 3) is also positive but not significant at 10 percent level. The education of the head variable is defined in terms of level of education ED1, ED2, ED3, and ED4 corresponding to less than 4, 5-8, 9-11, and above 11 years of schooling respectively and introduced as dummy variables (column 4). The effect of variables ED2 and ED3 are not significantly different from ED1, which is the reference group. The variable ED4 is significantly different from ED1. The results show that the education level above 11 years of schooling has a significant effect on the probability of adoption of HYV of paddy seeds. This implies that higher level of education is required to better understand, decode new information and utilise in an effective way.

The extension contact, one form of non-formal education, has a positive and statistically significant (at 1 percent level) effect in both continuous and dummy variable forms in all the specifications. The results show that the extension contact is much more important than education in increasing the probability of adoption of HYV of paddy grains.

The probability of adoption of HYV of paddy seeds tends to increase with the availability of credit facilities and decrease with the age of the head. The negative effect of age may be explained in terms of the possibility of the more aged farm operators being more relectuant to use more modern techniques.

The maximum likelihood logit coefficient estimates of adoption of High Yielding Varieties in multicrop production are given in Table 5.

Since we are unable to compute the weighted average price of output from our data, it is not included in any of the specifications.[3] The credit dummy variable is also omitted, because most of the farmers have utilised credit facilities for one or the other crop.

Wage variables have a positive effect and the coefficients turn to be significant at 5 per cent in all the specifications. As we have already explained in the context of

TABLE 5

MAXIMUM LIKELIHOOD LOGIT COEFFICIENT ESTIMATES : ADOPTION OF HIGH YIELDING VARIETIES IN MULTICROP PRODUCTION, TAMIL NADU, INDIA, 1980-81

Dependent Variable: Adoption of High Yielding Varieties-dichotomous

	Independent variables	1	2	3	4	5
	Constant	-4.739 (6.491)	-4.798 (6.055)	-4.837 (6.337)	-4.919 (6.385)	-4.873 (4.453)
P_1	Labour wage (ln)	0.647 (2.895)	0.755 (3.140)	0.697 (3.012)	0.758 (3.195)	0.755 (3.139)
P_f	Fertilizer price (ln)	0.296 (1.043)	0.275 (0.942)	0.172 (0.587)	0.182 (0.620)	0.279 (0.955)
P_a	Price of animal input (ln)	0.045 (0.251)	-0.219 (0.116)	-0.046 (0.244)	-0.062 (0.326)	-0.030 (0.157)
Q_K	Capital (ln)	0.251 (2.446)	0.255 (2.367)	0.246 (2.311)	0.256 (2.425)	0.254 (2.359)
Q_T	Land (ln)	0.932 (4.468)	0.587 (2.599)	0.677 (3.048)	0.671 (3.007)	0.550 (2.348)
R	Region dummy	0.955 (3.578)	0.609 (2.108)	0.942 (3.427)	0.890 (3.207)	0.600 (2.072)
E	Education of head (years)		0.072 (2.059)			0.075 (2.043)
AE	Average education (years)					0.019 (0.535)
ED2	Education dummy ($4 \leq E \leq 8$)				0.555 (2.013)	
ED3	Education dummy ($9 \leq E \leq 11$)				0.750 (1.915)	
ED4	Education dummy ($E > 11$)				1.557 (2.577)	
ED5	Education dummy ($E \geq 4$)			0.682 (2.660)		
EX	Extension contact		0.027 (3.668)			0.026 (3.628)
EXD	Extension dummy ($EX > 0$)			0.697 (2.491)	0.625 (2.210)	
AGE	Age of head (years)					0.265 (0.137)
	-2 log likelihood	221.49	201.86	212.24	210.62	201.65
	N	461	461	461	461	461

Asymptotic 't' Statistics in parentheses (absolute) single crop production, this may be due to large scale participation of farm operators in the labour market. The fertilizer price variable is also positive in its effect contrary to our expectation, while the animal input price variables has the expected negative effect on the probability of adoption of HYv seeds. Both fertilizer price and animal input price variable coefficients are not significant at 10 level which may be due to the small variation in prices.

The value of capital service, net cropped area of land variables have the expected positive and statistically significant (at 5 percent level) effect. This implies that higher investment in fixed inputs will increase the probability of adoption of HYV in multicrop production.

The education and extension contacts of the head of the household, have a positive effect and the coefficients are statistically significant at 5 percent level in both continuous and dummy variable forms. Further the education dummy variables ED2, ED3 and ED4 corresponding to 5-8, 9-11 and above 11 years of education of the head respectively are also positive and significantly different from ED1, the reference group, at 5 percent level while ED2, is significant at 10 percent level. The average education of the adult family members also has a positive sign but not significant at 10 percent level may be because part of the effect is captured by the education of the head variable. These results further strengthen our hypothesis that education and extension enhance the probability of adoption of innovation in new techniques in farm production. The age of the head variable coefficient is also positive but that 't' value is low and not significant even at 25% level.

The log likelihood ratio test was conducted to examine the null hypothesis that the effect of education and extension variables on the probability of adoption is zero. The computed value is found to be lower than the critical value at one percent level implying that education and extension have significant effects on the probability of adoption.

To enable us to have a better understanding of the effect of the human capital variables, we also provide the marginal effects of education and extension variables on the probability of adoption of HYV in single and multi-crop production.[4] The results computed on the basis of the logit coefficient estimates are shown in Table 6.

From the table it can be seen that the increase in the education of the farmer by one year increases the probability of adoption of HYV by 1.5 and 1.6 percentage points in single and multicrop production respectively. In the case of a farmer who is educated rather than uneducated, the probability of adoption of HYV is increased by 5 and 15.5 percent for single and multicrop production respectively. Among the dummy variables corresponding to levels of education, ED4, which is more than 11 years of schooling, seems to be the most important variable, judging from its effect on adoption of HYV. The probability that a farmer with more than 11 years of schooling adopts HYV in single crop (multicrop) production is 26 (35) percent more than a farmer who has acquired 4 years or less of schooling.

TABLE 6

MARGINAL EFFECT OF EDUCATION AND EXTENSION SERVICE ON THE PROBABILITY OF ADOPTION OF HIGH YIELDING VARIETIES ; TAMILNADU, INDIA.

	Indenpendent Variable	Marginal effect (= $\bar{\bar{P}}$ $(1-\bar{P})\beta$	
		Single crop	Multicrop
E	Education of the head (yrs)	0.015	0.016
ED5	Education dummy (E $\geq$ 4)	0.050	0.155
ED2	Education dummy (4 $\leq$ E $\leq$ 8)	-0.009	0.126
ED3	Education dummy (9 $\leq$ E $\leq$ 11)	0.053	0.170
ED4	Education dummy (E > 11)	0.255	0.353
EX	Extension contact	0.031	0.006
EXD	Extension dummy (EX > 0)	0.246	0.158

Each extension contact increases the probability of adoption by 3 and 6 percent respectively in single and multicrop production. Farmers who have positive rather than zero extension contact find that the probability of adoption is higher by 25 and 16 percentage points in single and multicrop production.

5. INTENSITY OF USE OF HYV SEEDS

The dichotomous logit model of adoption, presented above, enable us to analyse the factors influencing the decision to adopt HYV. However, it ignors the extent and intensity of use of HYV. The effects of human capital and other variables on the degree or intensity of adoption of HYV is examined in this section.

The intensity of use of HYV is defined as the percentage of area under HYV to total cropped area of land (AHYV). The estimating equation is

$$AHYV = b_0 + b_1 \ln P_i + b_2 \ln Q_i + b_3 U_i + b_4 R_i + u_i \qquad (7)$$

where u_i is the stochastic disturbance term assumed to be normally distributed with zero mean and constant variance.[5]

The ordinary least squares estimates of equation (7) for multicrop production is given in Table 7. The labour wage has a positive coefficient and is also statistically significant at 5 percent level. Animal input price and fertilizer price have a positive effect but the coefficients are not significant at 10 percent level. Capital and land variables are positive as expected but, while the former is significant at 1 percent level in all the specifications, land is significant only in

TABLE 7

OLS REGRESSION ESTIMATES: PERCENTAGE OF NET CROPPED AREA UNDER HIGH YIELDING VARIETIES IN MULTICROP PRODUCTION TAMIL NADU, INDIA, 1980 - 81.

Dependent Variable: Percentage of net cropped area under High Yielding varieties

Independent Variable:		1	2	3
	Constant	-8.938	-7.844	-6.362
P_1	Labour Wage (ln) (Rupees)	10.909 (4.602)	11.169 (4.770)	10.777 (4.575)
P_f	Fertilizer price (ln) (Rupees)	2.416 (0.755)	2.079 (0.658)	2.516 (0.761)
P_b	Price of animal input (ln) (Rupees)	1.204 (0.655)	0.520 (0.286)	0.935 (0.511)
Q_K	Capital (ln) (Rupees)	4.529 (4.290)	4.449 (4.271)	4.574 (4.360)
Q_T	Land (ln)	4.677 (2.315)	2.367 (1.121)	3.006 (1.428)
R	Region dummy	15.517 (5.492)	13.860 (4.797)	13.509 (4.643)
E	Education of the Head (years)		0.880 (2.853)	
EX	Extension contact		0.051 (1.506)	0.085 (2.631)
R^2		0.348	0.369	0.358
F		40.355	33.040	36.030
N		461	461	461

't' values in parentheses.

equation 1. Region dummy variable also exerts a positive effect on the percentage area under HYV.

Education of the head and extension variables are positively and significantly related to the percentage net cropped area under HYV. When extension variable is introduced along with education, part of the effect is captured by education variable and so it loses its significance. The results show that one year increase in education of the head increases net cropped area under HYV by 1 percent. The effect of other explanatory variables such as age of the head, and average education of adult members of the household are in line with our earlier findings of the logit analysis and so the regression estimates are not presented.

The regression analysis for percentage net cropped area under HYV in single crop production also confirms our earlier findings using logit analysis and so the regression estimates are not reported.

6. CONCLUSION

The effect of education on the adoption of High Yielding Varieties of seeds in single crop paddy and multi crop production by the South Indian farmers has been analysed using a logit model of dichotomous choice. The results show that education of the head of the household and/or average education of adult members of the family and extension contacts have a positive and significant effect on the probability of adoption HYV, the effect being stronger in multi crop environment. Our findings thus support the innovative effect of education, proposed by Schultz (1975), and Nelson and Phelps (1966). These results provide a case for increased spending on rural education and intensifying extension services in order to increase the adoption and use of HYV seeds.

The economic variables such as price of output and inputs - labour, fertilizer and animal input - quantities of fixed inputs - capital and net cropped and area - and region dummy variables are also incorporated in order to study the impact of these factors on the probability of adoption of innovation. The results, in general, confirm our apriori expectations. The price variables, in some cases, turn out to be insignificant, which we believe is because our sample area is limited in its geographical coverage and as such there is very little variation in prices.

The impact of human capital variables on the intensity of use of HYV is examined by redefining the dependent variable as percentage net cropped area under HYV and estimated with ordinary least squares regression method. The estimates give further confidence in our earlier dichotomous logit analysis of the probability of adoption of HYV.

FOOTNOTES

1. Education and extension contacts of the farm operator not only enhances the innovative ability and help them to choose new modern and more productive inputs but also affects the productivity (worker effect) and optimum allocation of inputs and outputs (allocative effect). These two issues are examined in a companion paper (Duraisamy, 1988a). For a review of the effects of education on various market, and nonmarket activities, see Duraisamy (1988 b).

2. Multi response polytomous logit or probit model can be utilized to analyse the choice decision on selecting different varieties among HYV or traditional variety within a crop or choosing crops (Mc Fadden 1976). This approach requires large sampling. Since our data is not sufficient to analyse multi response decision, we have defined adoption decision as bivariate.

3. It is possible to compute price of output in multicrop production, as weighted average of outputs. Unfortunately we have not coded the output prices of each crop separately and hence we are unable to compute the price of output in multicrop production.

4. The marginal effect of education (E) and extension (EX) variables on the probability of adoption of HYV are computed from the logit parameter estimates (β_i) by using the formula.

   $$\partial P/\partial i = \beta_i \bar{P} (1 - \bar{P}), \; i = E, EX$$

   where $\bar{P}$ is the sample mean proportion of HYV users.

5. The dependent variable, namely. percentage area under HYV (AHYV) is limited in its range (0,100) but not concentrated at lower or upper bound. Maximum likelihood Tobit estimation procedure yields results similar to OLS and hence Tobit estimates are not presented.

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