Nepalese Horticulture 3(1) :9-20. 1999.

TECHNICAL EFFICIENCY IN VEGETABLE SEED PRODUCTION IN NEPAL*

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ABSTRACT

This study examined the technical efficiency in contractual vegetable seed production in the Eastern Hills of Nepal. It used primary data collected for a period of July 1996 to June 1997. A modified translog frontier production function was used to derive the efficiency measures. The measured mean technical efficiency in seed production was 89.68 %. It shows that production can increase by improving the technical efficiency thereby reducing per unit cost of seed. Farmers' education and experience can significantly improve efficiency. Production in more remote district was significantly lower than that in more accessible district. It was also related to the finding that farmers who visit technical information centers more frequently were technically more efficient than others. Moreover, farms farther from the source of inputs were technically less efficient. Because vegetable seed production is purely a market-oriented program, these findings point to the need to review the policy of encouraging vegetable seed production in remote areas.

Additional Key Words: Production function, Frontier analysis, determinants of efficiency, seed production.

INTRODUCTION

The Problem

Despite the fact that it is feasible to produce all types of vegetable seeds in Nepal, this question has remained unanswered: why could vegetable seed production not expand in Nepal as expected? Several reasons are brought forward. Seed growers say that procurement prices are generally too low and that seed traders often do not honor the production contracts (Werner, 1995). Studies have shown that when family owned resources like manure and family labor are included, the procurement price does not even cover the cost of production (LAC, 1992; Pandey et al., 1990). Growers have also complained about traders' ill intention to reduce the price of seed. Sometimes traders do not purchase even the contracted quantity (Singh, 1996). On the other hand, seed traders say that the government's current practice of fixing the procurement price of seeds in its program (AIC) is a serious obstacle to the promotion of a free seed market in the country. India offers stiff competition. The procurement price of seeds in Nepal is so high that they cannot compete with Indian seeds (Shrestha and Adhikari, 1996). Seed traders also complain about the low-quality seeds that the growers deliver. And, oftentimes the delivery is late (Singh, 1996).

The claims of both parties have no real basis. No policy options can be developed on the basis of such *ad hoc* recommendations. Producers as well as traders do not keep any farm management records and the true information on the cost of production is difficult to ascertain. If the procurement price that covers cost of cultivation is decreased such that it can compete with Indian seeds, then the traders' stand on reducing the cost of production to make Nepali seed competitive seems to be valid. This requires finding out whether per unit cost of production can

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[*] This paper is based on the author's Ph.D. Thesis (Economic Efficiency of Contractual Vegetable Seed Production in the Eastern Hills of Nepal) submitted to the University of the Philippines (UPLB) under the guidance of Dr. Agnes C. Rola, Associate Professor, Department of Agricultural Economics, College of Economics and Management, UPLB, Los Baños, Philippines.

be reduced through improved productivity. A study of technical efficiency in production and an evaluation of the determinants of efficiency can be helpful in this regard. If this is not achieved, then government will have to look for ways to improve the production technology through further research. In other instances, the price may cover the cost of cultivation, but the cost itself may be high due to inefficiency in production. If the procurement price of seed does not cover the cost of cultivation, information on the possibility of increasing production through increasing technical efficiency to reduce per unit cost will be necessary to help design policies for that purpose.

This study has attempted to provide such information in the contractual vegetable seed production program in Nepal. To examine the technical efficiency and its determinants in contractual vegetable seed production this study was conducted in the Koshi Hill Region of Nepal.

METHODOLOGY

Theoretical Framework

The question of efficiency in production arises when producers who face the same set of prices and production function fail to achieve the same level of production (Shapiro and Müller, 1977). Because production function is defined as the relationship that describes the maximum possible output for a given combination of inputs (Furguson, 1966) – that is, maximum production relates to the production frontier (Herdt and Mandac, 1981; Rola and Alejandrino, 1993), the producer has to achieve that maximum to be called as efficient in production. The presence of the inefficient producer now implies that the producer either failed to operate on the technically efficient production function (production frontier) or s/he failed to apply the level of input that maximizes profits. Such a failure to operate on the production frontier is referred to as technical inefficiency, and the failure to meet marginal conditions for profit maximization (i.e., failure to utilize the profit maximizing level of inputs) is referred to as allocative (or price) inefficiency. Finally, economic inefficiency is the product of technical and allocative inefficiencies (Shand and Kalirajan, 1993). These basic concepts of technical and allocative efficiencies are shown in Figure 1, for the one-input, one-output case. The curve Y_m shows the total possible maximum output. Y_a shows the average output as input X is increased. Since by definition, the curve Y_m is a frontier function, all the points below it give less output and are thus technically inefficient. Given the P_x (price of input X) and P_y (price of output Y), the firm is allocatively efficient with Y_1 level of production at X_1 level of input use. This is because at this level of production, the firm is able to meet the marginal conditions of profit maximization (Value of marginal product (VMP) = Marginal factor cost (MFC)). As depicted in Figure 1, a firm using X_2 level of input and producing Y_2 level of output is technically inefficient as given by $[1-Y_2/Y_3)]$ as point C is below the frontier function. Nevertheless, if the firm is able to get Y_3 level of output at the same X_2 level of input, then the firm is technically efficient as point B is on the frontier function.

However, at point B, the firm is not able to meet the marginal condition for profit maximization (at point B, the firm's VMP > MFC). The firm could increase the use of input X up to X_1 level to increase its profit to a maximum. Hence, the firm is allocatively inefficient at point B as given by $[1-(Y_3/Y_1)]$. Alternatively, these measures are — technical efficiency (TE) = Y_2/Y_3, allocative efficiency (AE) = Y_3/Y_1, and economic efficiency (EE) = Y_2/Y_1. In this paper, only the technical efficiency in production has been discussed in detail.

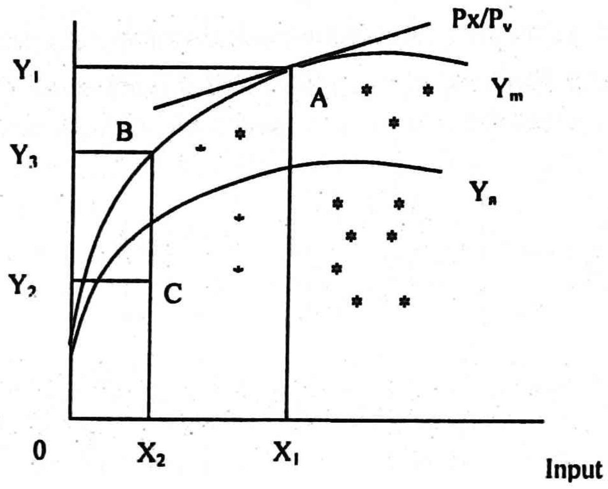

Figure 1: Technical and allocative efficiencies

As a better specification of production behavior, the transcendental logarithmic (translog) function is in increasing use in the literature (Parikh and Shah, 1994). Translog functions are flexible functional forms and do not encounter the problems of unitary and constant elasticity of substitution seen in Cobb-Douglas and CES production functions (Greene, 1993). In view of the flexibility provided by the translog function, a stochastic translog frontier production function of the following type was specified in this study.

$$\ln Y_j = \ln \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln X_i + \sum_{k=1}^{m} \alpha_k E_k + \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} \ln X_i \ln X_j + \sum_{i=1}^{n} \sum_{k=1}^{m} \alpha_{ki} E_k \ln X_j + \varepsilon_j \tag{1}$$

$$\varepsilon_j = v_j + u_j \tag{2}$$

where Y_j = quantity of vegetable seed produced by farm j; X_i = level of input i; E_k = environmental variables (dummies) affecting production; ε_j = disturbance term consisting of two independent elements, v_j & u_j ; v_j = random variation in output due to the factors outside of the control of farmers; u_j = technical inefficiency relative to the stochastic frontier.

The random symmetric disturbance term v_j is assumed to be independently and identically distributed as $N(0, \sigma^2_v)$. The inefficiency component u_j is also assumed to be independently and identically distributed half normal as $N(0, \sigma^2_u)$. Hence when $u_j=0$, then the production of the particular farm lies on the frontier. By the same token, when the $u_j<0$, then the production of that particular farm lies below the frontier, indicating the level of technical inefficiency.

Analytical Framework

In the estimation procedure, the decomposition of the disturbance term (ε) into u_j and v_j can be done by following Jondrow et al. (1982) and Aigner et al. (1977). Then the conditional distribution of u given ε gives the firm-specific technical efficiencies as follows.

$$E\left[u_j \middle| \varepsilon_j\right] = \sigma^{2*}\left[\frac{f(\varepsilon\lambda/\sigma)}{1-F(\varepsilon\lambda/\sigma)} - \frac{\varepsilon\lambda}{\sigma}\right] \tag{3}$$

where $\sigma^{2*} = (\sigma^2_u \cdot \sigma^2_v)/\sigma^2,\ \ \sigma^2 = \sigma^2_u + \sigma^2_v,\ \ \lambda = \sigma_u/\sigma_v$ (4)

f(.) is standard normal density function, and F(.) is standard normal cumulative distribution function.

Variables included in the model

Value of seed yield (Sy) - The value of all the contract-produced seeds was added together to get the value of seed production and was measured in rupees per ropani. **Value of seed input (Sv)** - The value of all the seed inputs was added together to get the value of seed input. This variable was also measured in rupees as total expenses made on foundation seed. **Manure (Mq)** - Manure in this study refers to any type of compost added to the field which was measured in terms of bhari (about 20 kg). **Urea (Uq)** - It is measured in terms of kilograms (kg). **Other nutrients (On)** was measured in terms of total expenses (Rs) made on all nutrients other than urea. **Pesticides (Pt)** represented in the cost (Rs.) of all chemicals added together. **Irrigation (Ir)** - To get a fair estimate of the price of irrigation, the total expenses made to irrigate a unit area once were used as price of irrigation water. This variable was thus measured in rupees as a cost of irrigation water per ropani. **Bullock power (Bd)** - Bullock power refers to the number of days of bullock used per ropani. **Labor (Ld)** - This was measured in labor-days by adding together male and female labor (for detailed explanation, see Thapa, 1998). Price of labor was measured in rupees per labor-day. **Transplanting dummy (Tp)** - The transplanting dummy is used to represent the state of production technology. It assumes a value of unity if the particular farmer transplants the seed crop, and zero otherwise. **Micronutrient deficiency in the soil (Mn)** - This variable assumes a value of unity if the farm has observed any micronutrient deficiency symptom in the seed crop, and zero otherwise. **Topography of land (Tl)** assumes a value of unity if the particular farm produces vegetable seed in Bari land, and zero otherwise (Khet land). **Crop rotation (Cr)** - This assumes a value of unity if the farmer grew the same crop last year in the particular seed crop field this year, and zero otherwise. **Location of the production sites (Z_i)** - To capture the effect of remoteness in production, the following district dummy (Z_i) was used in this study. $Z_D = 1$ if Dhankuta, $Z_T = 1$ if Tehrathum, $Z_B = 1$ if Bhojpur, and $Z_S = 1$ if Samkhuasabha, and zero otherwise.

Empirical Model

The conceptual translog model specified earlier was tested with all the variables in the full model. Depending upon the expected sign and significance of the estimated coefficients, the significance of the estimated σ, λ, F, and adjusted R^2, the translog model was modified. The modified translog model used in this study is as follows.

$$\begin{aligned} \ln Sy = {} & \ln \alpha_0 + \alpha_s \ln Sv + \alpha_u \ln Uq + \alpha_o \ln On + \alpha_i \ln Ir + \alpha_p \ln Pt + \alpha_b \ln Bd + \alpha_l \ln Ld \\ & + \tfrac{1}{2} [\alpha_{ss} (\ln Sv)^2 + \alpha_{mm} (\ln Mq)^2 + \alpha_{uu} (\ln Uq)^2] + \alpha_{mu} \ln Mq \times \ln Uq \\ & + \alpha_{mo} \ln Mq \times \ln On + \alpha_{mb} \ln Mq \times \ln Bd + \alpha_{pb} \ln Pt \times \ln Bd + \gamma_d Mn + \gamma_t Tl + \gamma_r Cr \\ & + \gamma_{sr} \ln Sv \times Cr + \gamma_{pr} \ln Pt \times Cr + \gamma_{ur} \ln Uq \times Cr + \delta_T Z_T + \delta_B Z_B + \delta_S Z_S + \varepsilon \end{aligned} \qquad (5)$$

where $_{ij} = {}_{ji}$ as symmetric restriction, and α_is, γ_is, and δ_is are the parameters to be estimated. The other variables and the disturbance term are the same as those mentioned in the preceding section.

By taking the first partial derivative of the given ln Sy function with respect to factor X_i, the output elasticity of the i^{th} factor has been estimated as

$$\eta_i = \partial \ln Sy / \partial \ln X_i \qquad (6)$$

The sum of these output elasticities gives a return to scale (θ) as:

$$\theta = \Sigma (\partial \ln Sy / \partial \ln X_i) \qquad (7)$$

The empirical model was estimated by MLE technique using the LIMDEP-6 computer package. By using the frontier regression results thus obtained, technical efficiency was computed as the ratio of the observed level of output to the technically maximum level of output [$TE = Y_{obs} / Y_{max}$].

Determinants of Efficiency

Even under the same production environment and while facing the same technology, farmers do have different levels of productivity in their respective farm. This is affected by various factors. In view of the effect of human capital and socioeconomic factors on production, the following variables are included to determine the contribution of such variables in achieving production efficiency in vegetable seed production. **Age (Age)** - Age of the head of household, measured as a continuous variable in number of years. **Education (Sch)** - Education level of the head of household, measured as a continuous variable in terms of number of years of schooling. **Experience (Exp)** - Experience of a farmer as a contract seed grower, measured as a continuous variable in terms of number of years. **Distance from the source of input (Dsi)** - Physical distance that a farmer has to commute from his farm to reach the nearest market center where he gets production inputs and sells his outputs, measured in terms of distance in kilometers. **Frequency of farmers' visit to technical information centers** - Frequency of farmers' visits to technical information as a dummy. $Frvd_1 = 1$, if the farmer visited the technical information center only once during the seed crop growth in the field (low visitors); $Frvd_2 = 1$, if the farmer visited the technical information center 2-3 times (moderate visitors); and $Frvd_3 = 1$, if the farmer visited the technical information center 4 or more times (frequent visitors), and zero otherwise. **Sex of the decision-maker (Sod)** - This variable assumes a value of unity if the decision maker is a male and zero otherwise. **Sex of the person in whose name the contract is signed (Sic)** - This variable assumes a value of unity if the contract is signed by a male and zero otherwise. **Membership in seed producers' association (Msa)** - Dummy for farmers' membership in any type of seed producers' association, assumes a value of unity if the farmer is a member of any type of seed producers' association, and zero, otherwise. **Farm size (Fsr)** - Total area of land under the control of the farm household, measured in ropani. **Enterprise risk (Ver)**

$$\text{Value of enterprise risk per ropani} = \frac{\text{Percentage of damage due to hazards} \times \text{Expected return}}{\text{Time interval of the occurrence of the hazards (years)} \times \text{Area planted}}$$

Empirical Model Specification

To evaluate the determinants of production efficiency, the following empirical models are estimated in this study.

$$\begin{aligned} TE = {} & a_0 + a_1 \,Age + a_2 \,Sch + a_3 \,Exp + a_4 \,Fsr + a_5 \,Ver + a_6 \,Dsi + a_7 \,Frvd_2 \\ & + a_8 \,Frvd_3 + a_9 \,Sod + a_{10} \,Sic + a_{11} \,Msa + e_t \end{aligned} \qquad (8)$$

where TE = technical efficiency indices computed from the estimated frontier production function; a_is are parameters to be estimated in technical efficiency determinant model and e_t is a random disturbance term in the model. Other variables are as defined in the preceding section.

The error term is assumed to be independently and identically distributed as $N(0, \sigma^2)$. With this assumption, the model was estimated by OLS technique.

The Data

In 1996/97 (July to June), there were 71 farmers in Samkhuasabha who produced vegetable seeds on contract. Similarly, there were 80 such farmers in Bhojpur, 95 in Tehrathum, and 168 in Dhankuta. The inclusion of 30 farms in the sample from each stratum (district) was deemed adequate for a study of this type (Upton, 1973; Yang, 1965). Hence, including 30 farms from Samkhuasabha, a proportional sample size was drawn from the rest (34 from Bhojpur, 40 from Tehrathum, and 71 from Dhankuta). The respondents were chosen randomly. This survey was conducted from May to July 1997.

PRODUCTION EFFICIENCY AND ITS DETERMINANTS

The modified stochastic translog frontier production function model was estimated by MLE technique using the Limdep-6 computer package. Data was tested using Durbin-Watson statistics for autocorrelation and Breush-Pagan chi-square test for heterocedasticity. The result did not show any such problems. All the results reported in the text were significant at the 0.10 level or more.

Production Function Estimates in Vegetable Seed Production

The value of adjusted R^2 was 0.8516 and the computed F statistic was significant (Table 1). As given by equation (4), the disturbance in the model was due to inefficiency reasons and random shock. The estimates show that 93.2 percent of the variation in production was due to inefficiency reasons. The random disturbances attributed 6.8 percent of the variation in production. The significant value of lambda implies that a major increase in production can be achieved by improving efficiency in production.

All the estimated output elasticities were positive. This implies that there will be an increase in the production of seed by increasing the use of any of the inputs. Besides the positive output elasticities, most of the variables included in the model had significant coefficients. Manure was found to be significant in squared term. This implies that manure is underutilized. Variables in the interaction term also had the expected signs. The term manure × urea was negatively significant. In remote areas where it is difficult to get fertilizers, farmers rely more on manure. However, if they do get fertilizers, they use it as a substitute for manure, thereby reducing the use of manure that is difficult to prepare and transport to the field by hauling. Because these two inputs are substitutes, the sign of the interaction term was negative.

Continuous cropping in sloping land leads to micronutrient deficiency conditions. In such a deficiency area, farmers are advised to use agricultural lime to reclaim the soil and also to use additional micronutrients during land preparation, and additional manure. Hence, the micronutrients were found to be the substitutes for additional use of manure to get rid of this problem. Thus, the expected negative relation was obtained between manure and other nutrients. Similarly, a negative sign between interaction of manure × bullock was obtained, as expected. This is because a well-manured soil is not compact and does not require much bullock power to plow the land.

The estimated coefficients of micronutrient deficiency condition dummy were negative and significant. This implies that the soil condition has been degraded significantly affecting agricultural production. The estimated coefficient of a land topography dummy was negative and significant. This means that cultivation in the sloping land is significantly lower than production in plain land. This is because sloping lands are eroded, less fertile, and more acidic than the plains. Crop rotation dummy was found to be negatively significant. It implies that if a farmer grows the same crop in the same piece of land the following year, production will be significantly lower. Crop rotation avoids serious soil-borne diseases like sclerotenia and black rots in crucifers. If a crop is not rotated, chemical measures have to be taken to control such diseases. Therefore, as expected, the interaction term between crop rotation × pesticides is positive.

The estimated coefficients of the district dummies were negative and significant. When the model was evaluated with respect to a particular district, these district dummies had a direct effect on the value of the constant. In the light of this effect, the estimated coefficients showed that Dhankuta District was best in the overall evaluation, followed by Tehrathum, Bhojpur, and Samkhuasabha. This shows that the more remote the production pocket, the poorer the performance of the vegetable seed production program.

The sum of output elasticities evaluated at the mean values of the respective variables was 0.7187. This implies that if the use of all inputs is increased by 100 percent, output will increase by 71.87 percent. This further implies that vegetable seed production in the area studied was characterized by decreasing returns to scale.

Efficiency in Vegetable Seed Production

Production efficiency among vegetable seed growers in the Koshi Hills is examined in terms of their technical, allocative, and economic efficiencies in production. Technical efficiency was estimated by applying equation (3) from the estimated frontier production function. The Limdep-6 version of the computer package directly gives estimates of the farm-specific technically maximum level of production. The technical efficiency was then estimated as the ratio of the observed level of production to this technically maximum level of production.

Table 1 Stochastic frontier production function estimates in vegetable seed production in the Koshi Hills (1996/97)

Variable	OLS estimates	ML estimates
ln constant	6.4122*** (0.1758)	6.4939*** (0.1739)
ln Sv	- 0.2085*** (0.0516)	- 0.1935*** (0.0509)
ln Uq	0.1314* (0.0720)	0.1417* (0.0778)
ln On	0.0207** (0.0102)	0.0211** (0.0099)
ln Ir	0.0142^{ns} (0.0103)	0.0133* (0.0074)
ln Pt	0.0282^{ns} (0.0249)	0.0401^{ns} (0.0283)
ln Bd	0.0982^{ns} (0.1166)	0.1077^{ns} (0.1576)
ln Ld	0.2709*** (0.0319)	0.2637*** (0.0315)
(½) (ln Sv)^2	0.0639*** (0.0125)	0.0582*** (0.0126)
(½) (ln Mq)^2	0.0686*** (0.0158)	0.0673*** (0.0186)
(½) (ln Uq)^2	- 0.0101^{ns} (0.0082)	- 0.0126^{ns} (0.0112)
ln Mq × ln Uq	- 0.0606** (0.0291)	- 0.0648** (0.0312)
ln Mq × ln On	- 0.0057^{ns} (0.0039)	- 0.0061^{ns} (0.0378)
ln Mq × ln Bd	- 0.0686^{ns} (0.0602)	- 0.0675^{ns} (0.0588)
ln Pt × ln Bd	0.0289*** (0.0091)	0.0274^{ns} (0.0290)
Mn dummy	- 0.0997*** (0.0187)	- 0.1067*** (0.0182)
Tl dummy	- 0.0433** (0.0195)	- 0.0376** (0.0189)
Cr dummy	- 0.7596*** (0.1964)	- 0.6871*** (0.1920)
ln Sv × Cr	0.0448*** (0.0146)	0.0439*** (0.0138)
ln Pt × Cr	0.0859** (0.0351)	0.0729* (0.0382)
ln Uq × Cr	0.3560* (0.0200)	0.0388^{ns} (0.0271)
Z_T dummy	- 0.0601** (0.0241)	- 0.0749*** (0.0238)
Z_B dummy	- 0.0880*** (0.0237)	- 0.1022*** (0.0219)
Z_S dummy	- 0.0926*** (0.0244)	- 0.1042*** (0.0270)
$\lambda = \sigma_u / \sigma_v$	-	3.6979*** (1.1620)
$\sigma = \sqrt{(\sigma_v^2 + \sigma_u^2)}$	-	0.1447*** (0.0111)
Adjusted R^2	0.8516	-
Log likelihood	-	178.40
F value	44.42***	-
No. of observations	175	175

Note:
*** , **, and * refer to significance at the 0.01, 0.05, and 0.10 levels, respectively.
ns = not significant. Figures in parentheses indicate standard errors.
Dependent variable = ln seed yield (value). ln = natural log.

The variation in technical efficiency ranged from 62.7 to 100 percent with a coefficient of variation of 8.66 percent. Mean technical efficiency was 89.68 percent. The presence of such a high level of inefficiency indicates that production (and thus returns from vegetable seed production) can be increased through proper evaluation of the determinants of efficiency and designing policy measures to improve it.

Determinants of Efficiency

The estimated farm-specific technical efficiency measure in vegetable seed production was further examined to evaluate the determinants of such a measure by regression analysis. The estimated value of R^2 was relatively low. However, the estimated F values and most of the coefficients were significant. The estimated coefficients and the standard errors are presented in Table 2.

The estimated coefficients of variables such as decisionmakers' education, farm size, value of enterprise risk, distance from technical centers, and membership of growers in any seed growers' association were found positive and significant in determining technical efficiency. The results show that an increase in schooling of the household head by one year will increase the technical efficiency by 0.32 percent. Education in general has a significant positive effect on the technical efficiency of farmers (Ali and Flinn, 1989; Baidya, 1986). Because vegetable seed production requires skills, farmers with better education achieve higher levels of production.

With a larger size of farm, farmers have incentive to acquire technical information through training and education. This even applies to farmers' visit to technical information centers to get information about production technology. This is because with a larger farm, the scale of production is also big and per unit cost of acquiring such information becomes smaller as compared with a smaller farm. In this regard, the positive and significant coefficient in this study is consistent.

Risk in vegetable seed production in the surveyed area is brought about by occurrence of hailstones. A technical recommendation to reduce this risk is to adjust the time of planting. With the higher levels of contract and the perception of risk, the value of risk is also higher. When it is more risky, farmers are more attentive to timely planting and will thus get higher return than those who are less attentive to this fact. This is consistent with the finding of this study–the value of risk is a positive and significant determinant of technical efficiency.

It was also found that farmers who visit technical information centers more frequently are technically more efficient than the ones who visit less frequently. Because the purpose of the frequent visit is to acquire information on production techniques, it helps farmers to perform agronomic operations in time and more accurately as required, leading to the higher levels of production. However, this is more feasible with farmers who live in the vicinities of such technical centers. These further confirm the results of production function which show that the farms in more remote areas have a lower level of production than the ones in the more accessible areas.

The estimated coefficient shows that a farmer who is a member of a seed growers' association is technically more efficient than one who is not a member. This relation was obtained because in Nepal, growers' associations in remote areas also perform like a farmers' cooperative–arranging farmers' training and providing inputs such as foundation seeds, pesticides, and information materials. This improves the farmers' skill in production.

This study supports the hypothesis that access to the source and timely supply of inputs is positively related to technical efficiency. The farther the farm from the source of inputs, the less efficient production was found to be.

One interesting finding of this study is that technical efficiency of the farm household also depends on the sex of the household head. It was found that farm households, where the decisionmakers are male, were technically less efficient in vegetable seed production than the ones where the decisionmakers are female. More interestingly, when the production contract was signed in the name of the male counterpart in the family, those farms are found to be less efficient than those whose contracts were signed by a female member of the family.

Table 2 OLS estimates of technical efficiency determinant model in vegetable seed production in the Koshi Hills (1996/97)

Variable	Estimated coefficients	Variable	Estimated coefficients
Constant	0.85976*** (0.03250)	Distance from the source of input	- 0.00324*** (0.00065)
Age	0.00030^{ns} (0.00043)	Moderate visitor to technical center dummy	0.02876*** (0.01081)
Education	0.00327** (0.00135)	Frequent visitor to technical center dummy	0.03249** (0.01255)
Experience	0.00193^{ns} (0.00221)	Gender of decisionmaker dummy	- 0.03492** (0.01421)
Farm size	0.00090* (0.00048)	Gender in the contract dummy	- 0.02974*** (0.01104)
Value of enterprise risk	0.00013* (0.00008)	Member of any seed growers' association dummy	0.02547** (0.01068)
Adjusted R^2	0.4234	F value	12.61***

Note:

***, **, and * refer to significance at the 0.01, 0.05, and 0.10 level, respectively.

ns refers to not significant. Figures in parentheses indicate standard errors.

CONCLUSIONS AND POLICY IMPLICATIONS

From the frontier regression results, it was found that production can increase by improving the technical efficiency of farmers. This study also identified farmers' education and experience as factors that improve seed production efficiency. Therefore, one way to increase productivity is to conduct educational programs such as training, visits, and giving further exposure to the seed producers.

The timely supply of inputs is necessary to achieve higher technical efficiency. The farms farther away from the source of inputs were technically less efficient. Major inputs in vegetable seed production like fertilizers, pesticides, and foundation seed are sold separately by separate agencies (foundation seed by government farms, fertilizer by AIC, and pesticides by private sectors) in Nepal. There is no coordination in the sale of these inputs. These three inputs are an integral part of modern production technology and for this reason, the supply of all three inputs at the right time and quantity must be assured. This can be done by promoting farmer's cooperatives which can handle input distribution.

In view of the need to maintain the physical and genetic purity of seeds, vegetable seed production requires highly skilled entrepreneurs. The results of the study have shown that farmers who visit the technical information centers more frequently are technically more efficient than the ones who visit less frequently. Farmers' visits to technical information centers also depend on the distance of the farms from such centers. This clearly indicates the need for setting up vegetable seed production programs around the vicinities of technical centers.

Besides the influence of distance from the source of inputs and technical information, several other factors are associated with remote areas. These areas are characterized by poor transportation system (which contributes to high cost of inputs), lower level of education and exposure of farmers (which contributes to lower skill in soil fertility and integrated pest management), and low incentives for the business sector to invest (which lead to imperfect markets). The cumulative effects of these factors affect production efficiency. The results of this study showed that remote districts like Bhojpur and Tehrathum were less efficient in production than Dhankuta which was closer to roads and input markets. This confirms the need to set up programs which require highly skilled workers (e.g., vegetable seed production) in more accessible areas.

These three recommendations now contradict the ad hoc recommendation of the agriculture development program in Nepal – that vegetable seed production programs should be established in the more interior parts of the country. A vegetable seed production program should not be viewed as a social program. It is a purely market-oriented program which has to compete with other sources of seed supply. This is mainly because, as in other quality-sensitive high value crops, vegetable seed is for markets at distant places including export. At this point, the policy of encouraging vegetable seed production in remote areas of the country must be reexamined.

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