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Technical Efficiency in Wheat Seed Production: A Case Study from Tarai Region of Nepal

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Abstract

In this paper, we measured the technical efficiency of wheat seed growers and identified the socio-economic variables influencing the efficiency. The data for the study were collected from three Tarai districts: Siraha, Chitwan and Kailali, representing eastern, central and far-western development regions of Nepal. Field survey was carried out in 180 households, representing 60 from each of the above districts. Stochastic frontier production model was estimated to measure the technical efficiency of farmers using crop yield as dependent variable against five inputs: source seed, labor, chemical fertilizer, livestock and operational land. The result shows the average efficiency of farmers in mobilizing above five inputs is 78.3% ranging from 38.6% to 94.6%. It means farmers could still increase their efficiency by 21.7% in wheat seed production. Nine socio-economic variables were regressed against technical efficiency score (as dependent variables) to identify their influence on technical efficiency, and the result shows that access to public irrigation source, and land quality have significant positive influence on technical efficiency. This shows that promotion of public irrigation scheme and land quality management measures should be prioritized in the agricultural extension policy to enhance efficiency of farmers in wheat seed production.

1. Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop of Nepal grown from Tarai[1] to hills as a winter season crop, and it shares 16% and 20% of the total calorie and total protein supplied from plant products in Nepalese diet. In 2009/10, this crop was cultivated in 0.73 million ha with the average yield of 2.12 t ha^{-1} (Ministry of Agriculture and Cooperative, MoAC, 2010). Though wheat is cultivated from Tarai to hills, the share of Tarai to the total area and total production of this crop is 59.3% and 69.3%, respectively. In spite of the great potential of wheat in food security, the yield of this crop has remained stagnant since 2000 (Tripathi et al., 2006) and various research and development efforts are underway to increase the current yield level, one being to increase farmers' access to improved seed[2]. It is because seed replacement rate (SRR)[3] of wheat in Nepal is <10% which is quite lower than the recommendation (25%) (Seed Quality Control Center, SQCC, 2011). To address the poor seed delivery issue in rural areas, development agencies and government actors have been empowering the farmer groups and cooperatives in producing and marketing of seeds of different cereal crops including wheat since mid 1990s (Witcombe, Devkota and Joshi, 2010). There are 128 registered farmers' groups and cooperatives involved in cereal crop's (including wheat) seed production and marketing in the country. In 2010, these organizations supplied >50% of the total wheat seed marketed in Nepal (SQCC, 2011). In the context of limited capacity of the government sector to supply seed in the rural farm communities, and poor attraction of big private companies in producing and marketing seed in cereals due to low profit margin, these farmers' initiatives have been considered potential instrument in supplying wheat seed in the rural areas (Poudel et al., 2003; Witcombe, Devkota and Joshi, 2010). Farmers' involvement in seed production has also been promoted in other developing countries of South Asia (e.g. Bangladesh and India) and Africa (e.g. Ghana, Zimbabwe, Kenya and so on) to address the poor seed delivery issue in the rural areas (Srinivas et al., 2010). Being a self-pollinated crop, farmers can easily multiply the source seed[4] produced in agricultural research station (government-owned organization), and after multiplying in their field, supply to other farmers through formal (packaging and labeling) and informal (e.g. bartering) means (Poudel et al, 2003). In spite of the great potential of these farmer-managed seed initiatives in the rural area, the performance of the farmers involved in wheat seed production is yet to be understood.

Measuring efficiency is the popular approach to understand the performance of farmers in mobilizing their resources in the given technology. Understanding efficiency of farmers in mobilizing their resources and factors influencing those efficiencies is important in developing countries as efficiency gain by farmers can contribute in economic gain (World Bank, 2011). This concept has resulted a number of past studies in efficiency and these studies have rejected the Schultz's hypothesis (Schultz, 1964) that 'poor people in the developing countries are efficient in utilizing their resources' (Kalirajan, 1999; Rahman, 2003; Piya, Kimanami and Yagi, 2012). Most of the previous efficiency studies of the developing countries are focused on rice and very limited studies are available on wheat (Hassan and Ahmad, 2005; Ghaderzadeh and Rahimi, 2008; Kamruzzaman and Islam, 2008; Dung et al., 2011; Sohail et al, 2012). The above studies on wheat have identified the existence of wide range of efficiency among the rural households ranging from 12% to 98%. In practical sense it is very difficult to compare the efficiency level of farmers from one study to another due to variations in choosing input variables. This necessitates the measurement of efficiency at local level using most commonly used input variables so that appropriate policy recommendation could be made. So, this study attempts to measure the technical efficiency of farmers using the most commonly used inputs: source seed, chemical fertilizer, labor, livestock and operational land, and identifies the socio-economic variables influencing efficiency of farmers.

This paper is organized as follows. In the next section, we discuss about the concept of stochastic production model and technical efficiency, the third section deals with methodology employed in the data collection and analysis, we present the empirical findings from this research in section four, and finally the fifth section concludes this paper.

2. Concept of stochastic frontier production function and technical efficiency

The concept of efficiency came in the literature once Farrell (1957) elaborated the idea about technical efficiency (TE) and allocative efficiency (AE). A firm is said to be technically efficient if its output falls on the frontier output (possible maximum output) in the given set of inputs, and similarly a firm is said to be allocatively efficient if it applies the inputs in appropriate proportion (by equating the ratio of marginal product of input with input price ratio) in the observed input price and output level (Battese and Coelli, 1995). The efficiency of the farmers can be measured from production (technical efficiency), cost (allocative efficiency) or profit functions (profit efficiency). Here, we discuss the efficiency of farmers from production perspective.

There are two types of parametric frontier production functions used in the literature in measuring the technical efficiency of farmers: deterministic and stochastic; however, the latter is considered more efficient than previous as it separates the random noise effect from the total residual (also called composed error) and gives consistent estimate for efficiency/inefficiency (Battese and Coelli, 1995). The theoretical idea of stochastic frontier production function (model) is that no one can produce output beyond the theoretically possible limit. The measurement of efficiency/inefficiency is thus possible how agents are far away from the limit. This model was originally proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) and its functional form is expressed as:

$Y_i = f(x_i; ß) \exp(v_i - u_i)$..................(1); Here, Yi is the quantity of production of $_i^{th}$ farm with $_i$ ranging from 1, 2...........n. x_i is the explanatory variable inputs, ß is the vector of parameters to be estimated, v_i represents the two-sided error term accounting for random variation in output due to factors outside the control of farmers such as measurement errors, disease and pests infestation in the field, natural calamities and so on. Another term u_i represents the error term associated with farm level technical inefficiency, and this inefficiency might occur due to variation in education, extension, and infrastructure and so on. Here, v_i is assumed to be distributed independent of each u_i and both errors are supposed to be uncorrelated with explanatory variables (x_i). The noise component v_i is assumed to have zero mean and constant variance (σ_u^2) and distributed normally; whereas inefficiency component u_i is assumed to have zero mean with variance (σ_u^2) and distributed half normally. As proposed by Aigner, Lovell and Schmidt

(1977), the log likelihood function for the half normal model is as given in equation 2. This likelihood function estimates whether the variation among the observations is due to inefficiency. From the likelihood function, we get σ^2 and λ^2, where $\sigma^2 = \sigma_u^2 + \sigma_u^2$ and $\lambda^2 = \sigma_u^2 |\sigma^2$. If $\lambda = 0$, there is no inefficiency effect and the variation in the data just due to random noise, and higher the value of λ reflects more inefficiency effect explained by the model

$$\ln L\,(Y_i|\beta,\sigma\lambda) = -\frac{1}{2}\ln(\pi\sigma^2) + \sum_{i=1}^{n} \ln \phi \left\{\frac{-\varepsilon_i\lambda}{\sigma}\right\} - \frac{1}{2\sigma^2} \sum_{i=1}^{n} \varepsilon_i^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots..(2),$$

Where, Y_i is the vector of log outputs, $\varepsilon_i = v_i\text{-}u_i = \ln Y_i - x_i ß$ is composite error term and $\phi(x_i)$ is a cumulative distribution function of the standard normal variable evaluated at x_i. The technical efficiency of farmer $_i$ in the context of stochastic production function can be expressed as:

$TE_i = Y_i/ Y_i^* = f(x_i; ß) \exp (v_i – u_i) / f(x_i; ß) \exp (v_i) = \exp (-u_i)$................(3),

Where, Y_i^* is the maximum possible output; Y_i, x_i, ß, v_i and u_i are as explained earlier. TE_i represents the technical efficiency. TE_i measures the output of farm relative to the maximum output that can be produced in the same level of input vectors. The value of TE_i ranges from 0 to 1. If $TE_i = 1$, Y_i achieves the maximum value of $f(x_i; ß) \exp (v_i)$, and $TE_i<1$ represents the shortfall of production from the maximum possible production level in the environment characterized by stochastic elements which vary across the farmers.

3. Methodology

3.1 Study area and sampling technique

This study was carried out in three Tarai districts: Siraha, Chitwan and Kailali of Nepal from October to November, 2011. Four community-based seed producers CBSPs)[4] having at least two years experience in production and marketing of wheat seed were selected from each of the above three districts in consultation with District Agriculture Development Offices (DADOs)[6]. From the total members engaged (ranges from 15 to 78) in wheat seed production of the above CBSPs, 15 members were randomly selected for household survey (where applicable), making the total sample size of 180. To complement the information collected from household survey, one group discussion in each CBSP was organized.

3.2 Empirical model

In this study we used the stochastic frontier production model to estimate the technical efficiency of farmers in production of wheat seed as described by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) using the two-stage procedure. In the first stage, technical efficiency was computed from stochastic frontier production model using Cobb Douglas functional form, and in the second step, technical efficiency (as dependent variable) was regressed against socio-economic variables of farmers using tobit model, where technical efficiency score varieties from 0 to 1. The stochastic frontier production model employed in this study is given as:

$\ln Y_i = \beta_0 + \beta_1$ ln source seed + β_2 ln labor force + β_3 ln chemical fertilizer + β_4 ln livestock + β_5 ln operational land + ε_i .....(4).

Here, ln represents logarithm, Y_i is wheat yield (kg ha^{-1}), β_0 ... β_5 are the parameters to be estimated. Source seed is the foundation[5] seed (kg) which is supplied to the farmers by government-owned agriculture research stations. Labor is the total labor force required to accomplish wheat seed production activity from land preparation to harvesting, and it was measured as labor force unit (LFU)[7] and used in the model. The value of chemical fertilizers (NRs. ha^{-1}) was calculated multiplying the amount of chemical fertilizers farmers applied in seed production plots with their unit costs.

Livestock is the integral component of Nepalese farming system, and farmers mostly use manure from livestock in crop field as a source of soil nutrients. There was no system of trading farm yard manure (FYM)[8] in the study area, and each household was found to use the manure whatever they have produced at their farms. So, to make consistency in the estimation of FYM, livestock standard unit (LSU)[9] was calculated and used as proxy for amount of FYM applied in the field. The operational land indicates the area under wheat seed production (ha). After estimating stochastic frontier production model (4), we predicted the technical efficiency using the formula given in equation (3) and the technical efficiency score was regressed against socio-economic variables using tobit model (5) to find out their influence on technical efficiency.

Tobit model is specified as,

$TE_i = \delta_0 + \delta_1$ age of HHH + δ_2 education of HHH + δ_3 family labor force + δ_4 training + δ_5 access to public irrigation source + δ_6 experience + δ_7 land rent + δ_8 off-farm income + δ_9 marketing + ω_i........(5), where, TE_i is the technical efficiency of farmers $_i$, δ represents the parameters associated with socio-economic variables, and ω_i is the error term. The description of socio-economic variables included in equation 5 and their hypothesized influence on technical efficiency is presented in table 1. Out of these variables, the response of age and education of HHH were hypothesized to have positive or negative (Ali and Flinn, 1989; Rahman, 2003). Training and experience in seed production are capacity enhancement variables, and these variables were supposed to have positive influence on technical efficiency (Rahman, 2003). Similarly, the influence of public irrigation source and land rent were also considered to have positive influence on technical efficiency due to their positive contribution on crop yield (Ghaderzadeh and Rahimi, 2005). Since majority of labor force in rural areas is supplied by family members, and easy accessibility of labor might positively contribute in the production. So, total family labor force was calculated as LFU[7] as discussed above, and it was hypothesized to have positive influence on technical efficiency. Similarly, seed production activity is seasonal in nature, and farmers' access to off-farm income was hypothesized to have positive influence on technical efficiency as off-farm income could contribute for timely accomplishment of the field activities. Participation of farmers in the marketing could increase their access to inputs for seed production (Witcombe, Devkota and Joshi, 2010), and it was hypothesized that farmers' participation in the market could have positive influence on technical efficiency.

Before running both stochastic frontier production model and tobit model, data were validated for multicollinearity and heteroskedasticity. The Variance Inflation Factor (VIF) method was used to detect multicollinearity among independent variables because this method is preferred over the correlation coefficient method (Pindyck and Rubinfield, 1981). We did not find any problem of multicollinearity while estimating both stochastic frontier production model and tobit regression as the values are <10. The test for homogeneity of variance was conducted using Breusch-Pagan/Cook-Weisberg test for heteroskedasticity, and the null hypothesis of constant variances of the residuals was accepted (p>0.3).

Table 1. Description and expected sign of socio-economic variables

Variables	Description	Expected sign
Age of HHH	Years	+/-
Education of HHH	Years of formal education	+/-
Training dummy	1= if any of the family members attended agriculture training, 0 = otherwise	+
Family labor force	Labor force unit (LFU)[7]	+
Public irrigation dummy	1= if household has access to public irrigation source, 0 = otherwise	+
Land rent	NRs./ha/season	+
Experience in seed production	Years	+
Marketing dummy	1= if household sold wheat seed, 0 = otherwise	+
Off-farm income	Cash income earned by household members in a year (NRs.)	+

Note: + indicates variables hypothesized to have positive influence on dependent variable, - shows variables hypothesized to have negative influence on dependent, and +/- indicates both

4. Results and discussion

4.1 Description of study households

All the sampled households are the farmers involved in wheat seed production with average operational land 1.14 ha. But only 50.8% of the total operational land is used for seed production. The remaining 49.2% of the total operational land left after wheat seed production is used to grow other crops such as vegetables, wheat as grain (for consumption), rapeseed, lentil and so on. The sampled households make their livelihoods from both on-farm and off-farm activities. On-farm activity (also known as agriculture activities) is the common income source in the study area. Over 90% of HHH adopt agriculture as their major occupation. The annual average cash income of households in the study area is NRs. 61,458. The share of on-farm cash income to the total household income is 53.4%. The households get on-farm income from diversified sources such as grains (42.2% households), livestock (59.4% of households) and others such as vegetable farming (35% of households). Income from seed production constitutes 32% of the total on-farm income; whereas, income from wheat seed shares 25% of the total seed income.

On average, off-farm income is higher than on-farm income but the number of households engaged in off-farm activities is limited (such as small business -23.3%, remittance -13.8%, salaried job within country- 45%).

4.2 Summary of study variables

Table 2 presents the summary statistics of the study variables. The upper part of the table presents the variables used in estimating stochastic frontier production model whereas the lower part of the table shows the household socio-economic variables hypothesized to influence technical efficiency. The variables are summarized with respect to their mean, standard deviation, minimum and maximum values.

As shown in the table (2), average wheat yield in the study area is 2,746kg ha^{-1} and it varies from 750 – 4,830kg ha^{-1}. The average yield is higher than the national average wheat grain yield (2,129kg ha^{-1}) (MoAC, 2010). There is also variation in source seed, labor, chemical fertilizer, livestock and operational land. In addition to above input variables, variation also exists in socio-economic variables. Average age of HHH is 46.8 years but it varies from 16 years to 78 years. In case of dummy variables, the mean value shows the percentage of farmers adopting that practice. The mean value of marketing 0.444 means that 44.4% of the households receive cash income from selling wheat seed in the market. There is also quite variation in land rent ranging from NRs. 3,000 ha^{-1} to NRs. 9,000 ha^{-1} per cropping season (i.e. 6 months starting from November until April) in the study area.

Table 2. Summary statistics of the study variables

Variable inputs	Mean	SD	Minimum	Maximum
Variables included in stochastic production frontier				
Wheat yield (kg ha^{-1})	2,746	833.6	750	4,830
Source seed (kg ha^{-1})	115.69	8.41	93.3	135
Labor (LFU ha^{-1})	62.6	11	35.8	73
Chemical fertilizer (NRs ha^{-1})	6,021	2,217	450	12,800
Livestock(LSU $farm^{-1}$)	3.88	12.97	0.1	221
Operational land (ha)	0.616	0.51	0.06	3.67
Variables influencing technical efficiency				
Age of HHH (years)	46.8	11.43	16	78
Education of HHH (years)	7.96	4.02	2	18
Labor force (LFU)[7] at household	3.4	0.37	2	20
Training dummy	0.78	0.41	0	1
Public irrigation dummy	0.233	0.42	0	1
Land rent (NRs/season/ha)	6,145	1,827	3,000	9,000
Experience (years)	4.37	0.97	1	10
Marketing dummy	0.444	0.23	0	1
Off-farm income (NRs/year)	42,998	52,622	0	281,083
Number of observations: 180				

Note: SD = Standard deviation, 1 US$ = NRs. 82.96 (source: Nepal Rastra Bank, 2011.11.30)
Source: Survey, 2011

4.3 Estimation of stochastic frontier production function

We estimated the stochastic frontier production model in Cobb Douglas functional form through maximum likelihood method using wheat yield as dependent variable and five inputs as independent variables. Table 3 presents the finding from this model. The likelihood ratio test[10] for "absence of inefficiency in the model" is rejected ($\chi^2 = 46.58$, $p = 0.0021$), and it indicates that inefficiency effect explained in the model is higher than random noise. Since the stochastic frontier production model was estimated through maximum likelihood method, the value of the coefficients (of input variables) does not represent the average response of these variables on wheat yield. So, we estimated the marginal effect[11] of input variables on wheat yield and these marginal effect values are used to discuss average response of input variables on wheat yield. As shown in table 3, all the input variables except labor have positive response on wheat yield. The marginal response of source seed on wheat yield is 0.38 which means wheat yield could be increased by 0.38% with 1% increase in seed rate. The result shows that at the current situation farmers use seed rate 115.69kg ha^{-1} which is less than the recommendation made in wheat production (120kg ha^{-1}) under irrigated condition in Tarai region of Nepal (MoAC, 2010).

The marginal effect of labor is -0.152 and it is significant at <5% level of significance which implies that 1% increase in labor leads to decrease in wheat yield by 0.152%. The reason behind the negative response of labor to wheat yield might be due to the fact that most of the labor involved in seed production is supplied by family members and they are unpaid, and in the absence of better job opportunities in the rural areas they could spend their time more than required in the farming. Sohail et al (2012) have also found similar result in case of Pakistan.

The study also shows the significant positive influence of chemical fertilizer on wheat yield though the amount of chemical fertilizer applied is less (N:P:K:: 54.5:36.3:19.38kg ha^{-1}) than the recommendation made by Nepalese government for irrigated wheat in the Tarai region (N:P:K:: 120:80:50kg ha^{-1}) (MoAC, 2010). Livestock has also shown positive response on crop yield though it is not significant. The response of operational land is significant, and it shows that 1% increase in operational land leads to 0.05% increase in wheat yield.

Table 3. Maximum likelihood estimates and marginal effects from stochastic frontier model

Variables	Coefficient ± Standard deviation	Z-value	P-value	Marginal effect†
Source seed	0.28±0.320	4.30	0.001***	0.38
Labor	-0.154±0.073	-2.09	0.037**	-0.152
Chemical fertilizer	0.315±0.054	5.79	0.002***	0.313
Livestock	0.012±0.02	0.60	0.549	0.13
Operational land	0.053±0.025	2.04	0.041**	0.055
Constant	2.01±1.53	1.31	0.189	
Log likelihood	-142.03			
Sigma^2 (σ^2)	0.139			
Lambda (λ)	3.42			
Total observations = 180				

† p-values of marginal effects are same to those of coefficients, ** and *** indicate significant at 5% and 1% levels, respectively.

4.4 Technical efficiency of farmers

The result shows that there is 78.3% efficiency of farmers in wheat seed production. However, it varies from 38.6% to 94.6%, meaning that farmers could improve efficiency in the wheat production by 21.7% (range 5.4 to 61.4%). Moreover, >70% households are above 70% efficiency level in seed production (Figure 1). Studies from other developing countries have also shown wide range of efficiency among the wheat growers. For example, Hassan and Ahmad (2005) reported 93.6% (range 58% to 98.5%) efficiency in mixed farming system of Pakistan. Similarly, Ghaderzadeh and Rahimi (2008) found the technical efficiency of farmers as 65.6% (range 30% to 94%) under rainfed wheat farming in Iran. Similarly Sohail et al (2012) estimated 60% technical efficiency (range 25%-85%) of wheat growers in Pakistan.

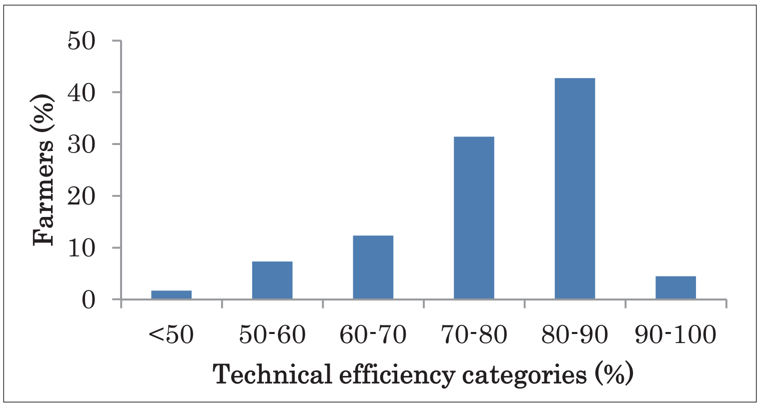

Figure 1. Distribution of farmers according to their technical efficiency categories

4.5 Socio-economic variables influencing technical efficiency

We estimated tobit regression to identify the influence of socio-economic variables on technical efficiency using maximum likelihood method. As in stochastic frontier model we also estimated marginal effect after estimating tobit model as the coefficients of independent variables (estimated from maximum likelihood method) do not show average response on dependent variables. Table 4 shows the results obtained from tobit model. Out of nine socio-economic variables hypothesized to have their influence on technical efficiency, the direction of response of seven independent variables on technical efficiency is as per our hypothesis, except to that of training and family labor force. Among these variables, access to public irrigation source, and land rent have significant positive influence on technical efficiency. We also estimated yield loss[12] due to inefficiency effect of the variables having significant influence on technical efficiency (Table 5).

Access to public irrigation source: This study shows significant positive response of public irrigation source on technical efficiency of farmers (Table 4). It means households having access to public irrigation source tend to be more efficient in wheat seed production than those who do not have access to this facility. This result can be further discussed comparing the observed yield, yield loss and technical efficiency score between households using public irrigation source and their counterpart. As shown in table 5, households using public irrigation source got 4.12% higher wheat yield, experienced 12.53% less yield loss, and operated at 5.3% higher efficiency level than those not using public irrigation source. The above result shows the importance of providing irrigation facility in the seed production area to enhance the efficiency of farmers in wheat seed production. In the study area only 23.3% of the households have access to public irrigation facility (water canal brought from the nearby river / stream through canal), and remaining 72.7% of households do not have that facility.

Table 4. Factors explaining technical efficiency in wheat seed production

Variables	Coefficient	Standard error	t-value	p-value	Marginal effect[13]
Age of HHH	0.031	0.031	1.02	0.129	0.029
Education of HHH	0.023	0.015	1.53	0.129	0.031
Training dummy	-0.016	0.018	-0.86	0.392	-0.012
Labor force	-0.01	0.024	-0.41	0.68	-0.001
Public irrigation dummy	0.03	0.02	1.5	0.028**	0.027
Land rent	0.152	0.029	4.23	0.000***	0.128
Experience in seed production	0.059	0.027	2.15	0.31	0.027
Off-farm income	0.008	0.0027	1.05	0.297	0.0037
Marketing	0.023	0.001	0.38	0.387	0.015
Constant	-0.318	0.273	-1.17	0.296	
Number of observations	180				
Likelihood ratio test	32.52***				
Log likelihood	151.68				
Pseudo R^2	0.22				

Note: **= significance at 5% level and *** = significance at 1% level.

Being situated in low altitudinal area, farmers could irrigate their crops using tube well irrigation but only 3% of the households have their own tube well at household, and majority of the households hire electric motor from neighboring farmers or from the market to irrigate wheat seed production field during crop establishment (i.e. after one month of seed sowing) and during flowering. Previous studies have also shown the positive response of public irrigation facility on technical efficiency of farmers (Wang, Cramer and Wailes, 1996; Sharma, Leung and Zaleski, 1999). The better response of public irrigation source to technical efficiency might be due to higher motivation of farmers to irrigate their crop field due to better access to irrigation, and lower irrigation cost than that of private irrigation sources. Also, better access to irrigation facility could motivate the farmers to combine other inputs (such as chemical fertilizer) for higher production (Wang, Cramer and Wailes, 1996; Ghaderzadeh and Rahimi, 2005).

Table 5. Comparison of observed yield, yield loss and technical efficiency among different household categories

Variables	n	Observed yield (kg ha^{-1})	Yield loss (kg ha^{-1})	Technical efficiency (%)
Access to public irrigation				
Yes	44	2,833	635	81.22
No	136	2,719	726	77.10
p-value ‡		0.03**	0.08*	0.04**
Land rent				
NRs. 3000 to NRs. 7000	143	2,504	733	79.72
More than NRs.7000	37	2,806	595	83.050
p- value‡		0.05**	0.013**	0.024**

‡ t-test was used to see whether the mean difference between two groups is significantly different from zero or not; n = number of households; *, and ** indicate significant at 10% and 5%, respectively

Land rent: We had used land rent in this study as a proxy indicator for land quality. There is significant positive influence of land rent on technical efficiency of farmers in wheat seed production. As shown in table 4, the marginal effect of land rent is 0.121 which means 1% increase in land rent leads to 0.121% increase in technical efficiency of the farmers in wheat seed production. It means households evaluating their land as more quality land tend to be more efficient than those evaluating their land as lower quality land. In a focus group discussion farmers argued that soil fertility and irrigation facility are the major determining factor for estimating land quality by farmers. The land rent is divided into two parts (those estimating their land rent from NRs. 3,000 to NRs. 7000 per cropping season per ha, and those evaluating their land rent above i.e. more than NRs. 7,000 per cropping season per ha) and compared their relationship with observed wheat yield, yield loss due to inefficiency and technical efficiency score . As shown in Table 5, households evaluating their land as of better quality (those estimating their land rent > NRs. 7,000/ha/season) got 12.06% higher yield, experienced 18.8% less yield loss, and operated in 4.17% higher efficiency level than their counterparts. The positive response of land quality on efficiency of wheat production was also reported by previous studies (Sharma, Leung and Zaleski, 1999; Kamruzzaman and Islam, 2008).

The other variables: age and education of HHH, training, labor force at household, experience of farmers in seed production, off-farm income and marketing do not have significant influence on technical efficiency of farmers.

5. Conclusion and policy implication

In this study, we measured the technical efficiency of Nepalese farmers involved in wheat seed production using stochastic frontier production model, and also identified the influence of socio-economic variables on technical efficiency using tobit model. The result of stochastic frontier production model shows that source seed, chemical fertilizer and operational land have significant positive influence on wheat yield but labor has significant negative influence on yield. The technical efficiency of farmers in mobilizing these resources in wheat seed production is 78.3% meaning that there is still 21.7% inefficiency among the farmers. Moreover, the result of tobit regression shows that access to public irrigation source and land rent (land quality) are the important socio-economic variables which have significant positive influence on technical efficiency of farmers in wheat seed production. These findings can have policy implication in seed policy or agricultural extension policy of Nepal or other developing countries. The first policy implication from this study is about access to public irrigation source to farmers. It means, efficiency of the farmers could be improved in wheat seed production in the study area if public irrigation facility is provided. So, public irrigation scheme should be promoted in the study area utilizing existing rivers/stream or providing subsidy to the farmers for setting up the underground irrigation schemes such as tube well. The second policy implication from this study is improvement of land quality, and enhancement of soil organic matter is one of the important aspects for improving land quality. Previous studies have also shown that most of the soils in the Tarai region of Nepal are deficit in organic matter content (Tripathi et al., 2006; MoAC, 2010). So, more effort is needed from government and other extension agencies (such as non-government organization) to motivate the farmers for the adoption of soil organic matter enhancement technologies such as quality improvement of FYM, integration of legumes in the wheat-based cropping system.

Endnotes

[1] Low altitude of Nepal ranging from 75m amsl to 250 m amsl

[2] Seed produced from foundation seed. The minimum quality standard of improved seed with reference to germination percentage, physical purity, etc set by countries' seed policy.

[3] The proportion of improved seed supplied to the total requirement

[4] CBSPs are the farmers groups and cooperatives involved in production and marketing of seed

[5] Seed produced from breeder seed and supplied to farmers' groups/cooperatives for multiplication.

[6] The district-level government organization mandated for agriculture extension

[7] LFU is the measurement of labor force, where people from 15-59 years old regardless of their sex were categorized as 1 person = 1LFU, but in case of children (10-14 years old) and elderly people (>59 years old) 1 person = 0.5 LFU

[8] FYM = Manure obtained from livestock

[9] LSU is the aggregates of different types of livestock kept at household in standard unit calculated using the following equivalents; 1 adult buffalo = 1 LSU, I immature buffalo = 0.5 LSU, 1 cow = 0.8 LSU, 1 calf = 0.4 LSU, 1 pig = 0.3 LSU, 1sheep or goat = 0.2 LSU and 1 poultry or pigeon =0.1 LSU (CBS, 2003; Baral, 2005)

[10] Log likelihood ratio (LLR) test = -2{log [Likelihood (H_0)]-Log [Likelihood (H_1)]} (Rahman, 2003)

[11] Marginal effect in stochastic frontier model = e(y)/ex = $ß_j$y (where $_J$ = 1, 2....n), here y is dependent variable i.e. observed wheat crop yield, j indicates types of input variables (1, 2....n), ß is coefficient to be estimated, e is the exponential function, x represent vector of input variables (Wooldridge, 2006)

[12] Yield loss = Maximum possible production – observed production, and maximum possible production = Observed production / technical efficiency (Rahman, 2003)

[13] Marginal effect in tobit model $\frac{\partial[y]}{\partial x_j} = \emptyset\,(\frac{x_{i\beta}}{\sigma})\,\beta_j$, where $\emptyset$ is cumulative density function

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