SAARC J. Agric., 20(1): 197-208 (2022) *DOI: https://doi.org/10.3329/sja.v20i1.60521*

TECHNICAL EFFICIENCY IN POTATO CULTIVATION IN BRAHMAPUTRA VALLEY OF ASSAM, INDIA

R. Bordoloi and A. Lama*

Department of Economics, Rajiv Gandhi University, Itanagar, Arunachal Pradesh, India

ABSTRACT

Potato is abundantly grown in Assam and is an important source of income and employment in rural areas of the state. But the productivity of potato in the state is low as compared to other states. Among the various factors, productivity of a crop is significantly influenced by technical efficiency. This paper examines productivity and technical efficiency in potato cultivation in Brahmaputra Valley of Assam, India. The study is based on both secondary and primary data. Primary data were collected from a sample of 400 potato growers. The study applied stochastic frontier production function to estimate technical efficiency and employed logistic transformation model of regression analysis to examine the determinants of technical efficiency. The results showed that potato productivity was positively and significantly affected by seed, fertilizer and manure costs. The mean level of technical efficiency among the farmers was 78%. Technical efficiency was found to be the highest in semi-medium and large land holdings. Technical efficiency was positively affected by land size and negatively affected by capital-labour ratio. The study implies that there is a need to promote use of quality seeds and plant nutrients to improve productivity and encourage extensive farming and use of labour to enhance technical efficiency in potato cultivation.

Keywords: Potato, Productivity, Technical efficiency, Frontier production function, Assam

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops in the world. It is considered as the poor man's food as is relatively cheap and abundantly grown in all climatic conditions. Potato is rich in carbohydrate and contains starch (16.1 g/100 g), protein (2.1 g/100 g), vitamin C (17.1 g/100 g), potassium (443 mg/100 g) and amino acids in fresh weight (Bajracharya and Sapkota, 2017). Potato plays a vital role in improving health and nutrition factors of the people in the rural areas of developing countries. Its cultivation is relatively profitable and provides cash income

* Corresponding author: lama_rgu@rediffmail.com

Received: 16.06.2021 *Accepted: 04.04.2022*

to the farmers (Sujan et al., 2017). The yield and gross return of potato are higher than the other competitive crops (Akhter et al., 2001) and has potential to generate income and employment to the rural people as it is a labour- intensive crop (Singh et al., 2019). So, it is considered to have a great potential to ensure food security of people in developing countries (Dube et al., 2018). India occupies a prominent position in the world in terms of potato production (Rana et al., 2018). It is the second largest producer of potato in the world with total production of 51.31 million tons from 2.14 million hectares of area (Government of India, 2018a).

Potato is one of the important crops grown in eight states of North Eastern Region (NER) of India. The eight states of NER namely, Assam, Arunachal Pradesh, Mizoram, Nagaland, Manipur, Meghalaya, Sikkim and Tripura together account for about 10% of the total area under potato in the country. Among the states of NER, Assam accounts for the highest area under Potato (Yadav and Srivastava, 2014). In fact, potato is widely cultivated vegetable crops of Assam and ranks fourth in terms of acreage under individual crop in the state (Borah, 2016). The state has 77.83 thousand hectares of area under potato followed by Meghalaya (18.2 thousand hectare) and Sikkim (6.8 thousand hectare). Assam contributes about 2.21% to the total potato production of the country (Government of India, 2018b). The production potato in the state increased from 6.77 lakh metric tons (MT) in 2000-01 to 7.2 lakh MT in 2017-18. The increase in production was mainly on account of area expansion as productivity grew very marginally. The yield rate of potato in the state was 7.0 MT ha^{-1} in 2017-18, which was much lower as compared to 29.9 MT ha^{-1} in West Bengal and 25.3 MT ha^{-1} in Uttar Pradesh and national average of 24 MT ha^{-1} (Govt. of India, 2019). The productivity can be raised by improving resource use efficiency or adopting new technologies (Dube et al., 2018). Technical efficiency estimates help in deciding whether there is a need to improve efficiency or adopt new technology for enhancing productivity of the crop. Hence, this study was undertaken to examine the technical efficiency and its determinants in potato production in Assam.

Technical efficiency measures the ability of a farmer to achieve the maximum output with given inputs and obtainable technology (Khai and Yabe, 2011). Output oriented technical efficiency is measured as the ratio of observed output to maximum feasible output (Jondraw et al., 1982; Udoh and Falake, 2006). The potential output can be measured by fitting the frontier production function technique. There are several studies on production and productivity of various crops which have reflected the importance of technical efficiency in increasing agricultural output. For example, Shanmugam and Venkataramani (2006**)** examined the technical efficiency of agricultural production in various districts of India. The study found that due to the lack of efficiency, agricultural production of India was low as compared to international level. Applying Cobb-Douglas stochastic production frontier approach, Abedullah and Ahmad (2006) estimated technical efficiency in potato production in Pakistan. The study found that 84% of potato farmers were technically efficient. Pandit et al. (2007) measured the technical efficiency among potato growers of

Barpeta district of Assam at 78% by employing the data envelopment analysis. Sharma et al. (2008) found that there was a considerable potential to increase output of cereal crops by improving technical efficiency in Himachal Pradesh. Dube et al. (2018) estimated the mean technical efficiency to be 89% among the smallholder potato farmers in Bale zone, Ethiopia by using stochastic frontier approach.

The review of literature revealed that the study of technical efficiency is important to identify the level of technical efficiency and its determinants. It can help in adopting necessary steps to improve farm productivity and agricultural growth. However, there is lack of comprehensive study on the technical efficiency in potato cultivation in north east India. Therefore, an attempt has been made in this paper to examine the level of technical efficiency and its determinants in potato cultivation in Brahmaputra valley of Assam.

MATERIALS AND METHODS

The study was based on both primary and secondary data. The secondary data were collected from various sources like statistical handbook of Assam, Economic Survey of Assam, Ministry of Agriculture, Government of India. Primary data were collected by conducting survey in the study area during 2018-2019. The survey was based on multi-stage random sampling technique. In the first stage, four districts of Assam namely, Barpeta, Nagaon, Biswanath and Sonitpur on the basis of their contribution to potato production. These districts together account for about 24.77% of total production of potato in the state (Government of Assam, 2018). In the second stage, two blocks were selected from each district on the basis of distance from the district head quarter. One block located near the head quarter and other block located away from head quarter was selected. In the third stage, from each block two villages were selected on the basis of the distance from the block head quarter. However, stratified random sampling technique was used to select the farmers. In the final stage, proportional sampling method was applied to selected the number of farm households from each district for data collection. In total sixteen villages (16) were surveyed and sample size was 400 farm Households. The sample size (n) was determined by using Yamane (1967) sample selection criteria. The formula is as follows:

$$\text{Sample size (n)} = \frac{N}{1+N(e)^2}$$

Where, N is the population and e are margin of error at 95% confidence interval.

As per Census 2011, there were 801105 farm households in the districts selected for the study. Putting this value (N=801105) in the above formula the sample size (n) was found to be 400 farm households.

The survey was undertaken by using structured questionnaire. The questionnaire was designed to collect information relating to socio-economic characteristics of the farmers. It was also designed to collect information relating to production activities such as net sown area, level of input used, cost and output. The required data were collected through direct personal interview method.

Analytical technique

The concept of technical efficiency was first proposed by Farell (1957) who introduced the frontier production function to measure the efficiency of a productive unit (Lama and Bordoloi, 2020). Technical efficiency is defined as the ratio of the actual output to the potential output. Thus, if the actual output is below the potential (frontier) output, then there is a technical inefficiency indicating that there is a scope to increase output with the same inputs through reallocation of resources.

$$\text{Technical Efficiency (TE)} = \frac{\text{Actual output}}{\text{Potential output}}$$

The Stochastic Frontier Approach (SFA) developed by Aigner, Lovell and Schmidt (1977) was applied to estimate the technical efficiency, assuming given technology and prices. The estimation was done by taking the Cobb-Douglas production function. In the Stochastic Frontier, the disturbance term consists of two components, one component representing technical inefficiency and the other representing the usual random noise. The actual production function can be written as;

$$Y_i = f(X_i; \beta) \exp(-u_i) \text{ and } 0 < u_i < \infty \text{ ; } I=1,2\ldots,n \text{ ---------- (1)}$$

Where Y_i = Actual output for the i^{th} sample unit; X_i = Vector of inputs used by the farm; β is the vector of parameters that describe the transformation process and u_i is a residual term that captures the effect of inefficiency. If the production unit is inefficient, then its actual output is less than the potential output (Shanmugam and Venkataramani, 2006). Thus, by using equation (1), we can write the measure of the technical efficiency (TE) of the production units as below:

$$TE = Y_i / f(X_i; \beta) = \exp(-u_i) \text{---------- (2)}$$

If TE is less than one, the actual output is lower than that of potential output and vice versa. Again, u_i is zero if the production unit produces the potential output. In order to capture the effect of other omitted variables that can influence the output, a random noise variable v_i is included in the equation (1) i.e.

$$Y_i = f(X_i; \beta) \exp(v_i - u_i) \text{ ---------- (3)}$$

Where v_i represents a random noise variable which is assumed to be independently and normally distributed. The parameters of the stochastic frontier production were estimated by using the maximum Likelihood method. Technical efficiency in potato was estimated by taking output per bigha as the dependent variable and seed, labor, fertilizer, manure, chemical and machinery used per bigha as the explanatory variables. The relationship between inputs and output and technical efficiency was estimated by applying the stochastic production function assuming Cobb-Douglas Production Function.

The determinants technical efficiency was obtained by applying the logistic transformation model. The variable (TE) was transformed into a new variable (Y*), where Y* = In (TE/1-TE) such that Ordinary Least Square (OLS) technique could be

applied to estimate the parameters (Kundu, 2012). The model used to identify the determinants of technical efficiency is as follows.

$$Y^* = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \varepsilon_i$$

Where,

α – stands for technological parameter

$\beta_1, \beta_2 \ldots\ldots \beta_{10}$ and $\delta_1 \ldots \delta_3$ are regression co-efficient representing output elasticity

X_1 is the experience in years (age has been taken as a proxy of experience), X_2 is the education; X_3 is the farm size; X_4 is the land-labour ratio; X_5 is the capita-labour ratio; X_6 is the share of rented land; X_7 is the share of area under HYV seed; D_1 is the district dummy variable, where, 1= Barpeta, 0= others; D_2 is the district dummy variable where 1= Nagaon, 0= others; D_3 is the district dummy variable where 1= Biswanath, 0= others. Here district dummy variable were taken to capture the influence of agro-climatic condition; e_i is the error term.

RESULTS AND DISCUSSION

Productivity and technical efficiency

The productivity of potato among the farmers was found to vary from 1000 kg to 7000 kg per bigha. The average productivity of potato among the farmers was about 3676 kg per bigha. It showed that medium size holdings were the most productive followed by semi-medium and large holdings. The small holdings were the least productive one. Descriptive statistics of the potato productivity and inputs are given in Table 1.

Table 1. Descriptive statistics of the inputs used by surveyed farmers

Variables	Mean	Std. Deviation	Minimum	Maximum
Productivity (in kg)	3676	1255.14	1000	7000
Fertilizer (NPK) (in kg)	45.16	17.62	9.25	92.20
Pesticide cost (in Rs.)	317.66	174.73260	150	1200
Machinery cost (in Rs.)	2147.38	735.77	572	3775
Manure cost (in Rs.)	216.0825	431.74579		1800
Seed cost (in Rs.)	4882.4375	2407.19043	525	11000
Size of holding (in bigha)	8.7800	16.43283	.50	150

There are several factors which affect the productivity of the potato. In this study, productivity of potato was taken to be the function of fertilizer (NPK) (in kg/bigha),

pesticide/chemical cost (in Rs/bigha), manure cost (in Rs/bigha), seed cost (in Rs/bigha) and size of land holdings. Cobb-Douglas type production function was used to measure the determinants of the productivity of potato production. The results of the regression analysis for determinants of potato productivity are presented in the Table 2.

Table 2. Result of the Stochastic Cobb-Douglas Frontier production function analysis

Log Likelihood= -25.295 Wald Chi^2= 510.88 Prob> Chi^2=00

Variables	Co-efficient	Std. Error	t-value	p- value
Seed cost	0.377	0.021	18.21	00
Labour	0.021	0.105	0.20	0.841
Fertiliser cost	0.128	0.024	5.36	00
Manure cost	0.023	0.0048	4.76	00
Chemical cost	0.046	0.027	1.69	0.091
Machinery cost	0.038	0.034	1.13	0.257
Constant	3.664	0.5044	7.26	00
Sigma u	0.339			
Sigma v	0.018			

Under Cobb- Douglas production function, regression coefficient represents output elasticity. The results showed that among the variables, seed, fertilizer and manure costs were found to be positively affecting the potato yield and it was significant at 1% level of significance. This implied that higher expenditure on seed, manure and fertilizer leads to higher productivity. The coefficient of labour day was found to be positive but not significant at any level. Again, coefficient of chemical, machinery cost and size of holdings were found to be positive and but they were not significant at any level. Thus, the above analysis showed that seed cost, fertilizer, manure cost were the main determinants of Potato productivity.

Lal and Sharma (2006) in their study of potato productivity in Himachal Pradesh also found manure and fertilizer as the significant determinants of potato productivity. Lama (2018) also found manure and fertilizer as the determinants of productivity in agriculture of Arunachal Pradesh. While Kadian (2010) found seed quality as the significant determinant of potato productivity in Meghalaya and Nagaland.

The technical efficiency in potato cultivation among the sampled farmers varied from 33% to 96%. The mean technical efficiency was found to be 78% which shows that on an average a typical farmer was operating at 78% of its potential output. This implies that there was a possibility to increase output by 22% with the same resources by improving technical efficiency. This is similar to the finding of Pandit et

al (2007). Applying Data Envelopment Analysis, the study found mean technical efficiency of potato growers in Barpeta district of Assam to be 78%. While Lama and Bordoloi (2020) found mean technical efficiency of potato growers in Arunachal Pradesh at 88%. Dube et al. (2018) estimated mean technical efficiency of smallholder potato growers in Bale zone of Ethiopia to be 89%. The mean of technical efficiency of the four districts are presented in the Table 3.

Table 3. District wise average technical efficiency of surveyed farmers

Districts	Mean Technical Efficiency (%)
Barpeta	82
Nagaon	81
Sonitpur	67
Biswanath	79
All Districts	78

The Table 3 showed that the technical efficiency level of surveyed farmers was the highest in Barpeta district (82%) followed by Nagaon district (81%). The technical efficiency was the lowest in Sonitpur district (67%). It shows that there is a possibility to increase output with the same resources by improving technical efficiency level. The level of technical efficiency by land size is shown in Table 4.

Table 4. Technical efficiency level by farm size

Farm size	Mean technical efficiency (%)
Marginal	77.4
Small	71.8
Semi-medium	88.5
Medium	84.8
Large	87.5
All Holdings	77.8

The table 4 reveals that the semi-medium land holding had the highest technical efficiency (88.5%) followed by large holdings (87.5%). The small holdings had the lowest technical efficiency (71.8%). The relatively high technical efficiency in semi-medium, large and medium holdings indicates that large farmers are able to allocate the inputs in a better way than the small farmers.

The distribution of surveyed farmers by technical efficiency showed that most of the farmers had technical efficiency in between 80 to 90%. The details are shown in figure 1.

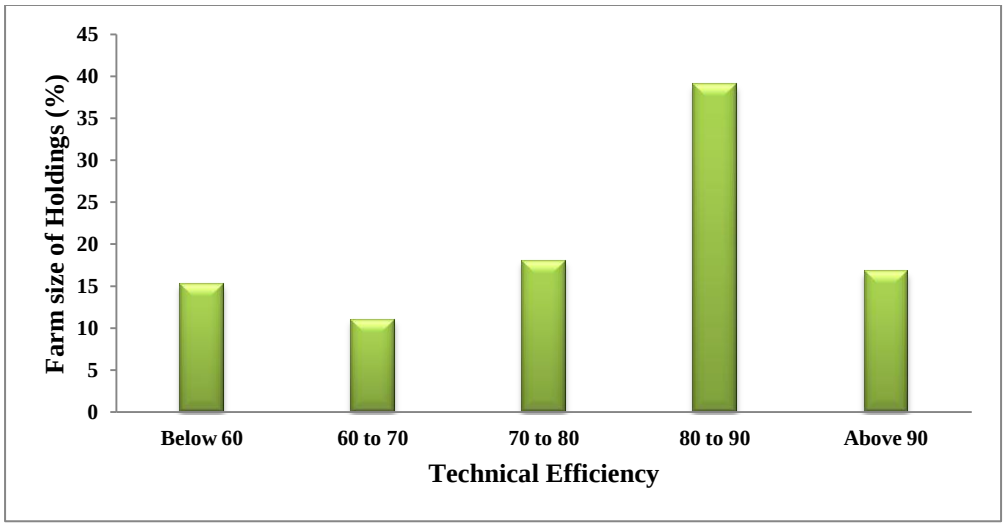

Figure 1. Percentage distribution of surveyed farmers by technical efficiency

It was found that 39% of the surveyed farmers had technical efficiency of 80 to 90% and 18% of them had technical efficiency of 70 to 80%. It was found that only 16.75% of the surveyed farmers had technical efficiency level of above 90% (Fig. 1).

Determinants of technical efficiency

The technical efficiency of a farm depends on a number of factors such as socio-economic variables and institutional factors. In this study, technical efficiency was taken to be a function of socio-economic variables such as education and experience (age), institutional and technical factors like farm size, land-labour ratio, capital labour ratio, share of rented land and share of area under high yielding variety (HYV seed). The multi-collinearity among the variables was tested by conducting the Variance Inflation Factor (VIF) and also by checking the tolerance level. The mean VIF of 2.50 was less than 10 (tolerance level) which indicated the absence of multi-collinearity problem among the independent variable. Breusch-pagan test for heteroskedasticity indicated absence of this problem. The determinants of technical efficiency were estimated by applying the logistic transformation model of regression analysis. The result of the regression analysis for determinants of technical efficiency is presented in Table 5.

Table 5. Result of regression for determinants of technical efficiency in potato cultivation

Variables	Co-efficient	Std. Error	t-Value	Sig.
Age	-0.0009	0.004	-0.24	0.807
Education (Dummy)	-0.0205	0.103	-0.2	0.842
Land size (Area)	0.0157*	0.003	4.61	0
Land-Labour Ratio	54.33*	11.691	4.65	0
Capital-labour Ratio	-0.4337*	0.114	-3.79	0
Share of Rented land	0.1061	0.119	0.89	0.375
Share of area under HVY seed	-0.0076*	0.001	-4.24	0
D_1(Barpeta)	1.234*	0.136	9.04	0
D_2 (Nagaon)	1.2721*	0.149	8.53	0
D_3 (Biswanath)	0.4368*	0.165	2.63	0.009
Constant	-0.1357	0.438	-0.31	0.757
F-Statistic	12.15			
R^2	0.238			

Note: (* Significant at 1% level)

The Table 5 eshowd the result of the regression analysis for determinants of technical efficiency in potato cultivation. The significant F-statistics showed that model was fit and R-square was 0.24. The variable land size had positive impact on technical efficiency and it was significant at 0.01 level of significance. The variable land-labour ratio was also found to have positive impact on technical efficiency and it was significant at 0.01 level of significance. However, the variable capital-labour ratio was found to have negative impact on technical efficiency and it was significant at 0.01 level of significance. This is because potato cultivation requires more labour work from preparation of soil, weeding and harvesting output. The share of area under HYV seed had negative impact on technical efficiency and it was significant at 0.01 level of significance. The district dummies D_1, D_2 and D_3 had positive impact on technical efficiency and each of the dummies were significant at 0.01 level of significance indicating higher technical efficiency in Barpeta, Nagaon and Biswanath districts as compared to Sonitpur district.

The results showed that farm size and land-labour ratio were the significant determinants of technical efficiency in potato cultivation. Both these variables had positive impact on technical efficiency. It implies that technical efficiency can be improved by promoting extensive cultivation of potato. The capita-labour ratio had negative impact on technical efficiency which indicates that technical efficiency in potato can be improved by increasing use of labour.

The findings of the study can be correlated to the findings of the other studies. Hossain et al. (2008) found that quality of potato seed had positive influence on technical efficiency. Dube et al. (2018) also found seed quality to have positive impact technical efficiency in potato production by smallholders in Kenya. Nyagaka et al. (2010) found education and access to extension service as the determinants of technical efficiency in potato production.

CONCLUSION

The study shows that potato cultivation can be an important source of sustainable income and employment in rural economy of the state. The productivity of potato in the state was much lower than the national average. At the same time, compound annual growth rate of potato yield in the state was quite low. The results showed that medium size holdings was the most productive followed by semi-medium. Among the various variables, productivity of potato was positively and significantly affected by seed cost, fertilizer (NPK) and manure cost. This implied that higher expenditure on quality seed, fertilizer and manure can help the farmers to obtain higher productivity of potato. The mean technical efficiency among the surveyed farmers was found to be 78%. Hence, there is a possibility to increase output by 22% with the same resources by improving technical efficiency. The technical efficiency in potato cultivation was positively affected by land size, land-labour ratio. It was negatively affected by capital-labour ratio and share of area under HYV seed. The findings of the study implies that there is a need to promote use of quality seeds and plant nutrients to improve productivity and encourage extensive farming and use of labour to enhance technical efficiency in potato cultivation.

ACKNOWLEDGEMENT

The authors are grateful to the authority of Rajiv Gandhi University, Rono Hills, Itanagar, Arunachal Pradesh for providing opportunities and extending support in conducting the research work.

REFERENCES

Abedullah, K.B. and Ahmad, B. (2006). Technical efficiency and its determinants in potato production, evidence from Punjab, Pakistan. *The Lahore Journal of Economics*, 2(2): 1-22.

Aigner, D.J., Lovell, C.A.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production models. *Journal of Econometrics*, 6: 21-37.

Akter, T., Pravin, T., Mila, F.A. and Nahar, A. (2019). Factors determining the profitability of rice farming in Bangladesh. *Journal of Bangladesh Agricultural University*, 17(1): 86-91.

Bajracharya, M. and Sapkota, M. (2017). Profitability and productivity of potato (*Solanum tubersum*) in Baglung District, Nepal. *Agriculture and Food Security*, 6: 47: 1-8.

Borah, S., Bowmick, B.C. and Hazarika, C. (2016). Production behavior of potato in Assam-a critical analysis across zones and size groups of farms. *Economic Affairs*, 61(1): 23-31.

Dube, A.K., Ozkan, B. and Ayele, A. (2018). Technical efficiency and profitability of potato production by smallholder farmers: the case of Dinsho District, Bale Zone of Oromia Region, Ethiopia. *Journal of Development and Agricultural Economics*, 1(2): 225-235.

Farell, M.J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, 120(3): 253-281

Government of Assam. (2018). Statistical Hand Book of Assam. Directorate of Economics and Statistics, Assam.

Government of India. (2011). Population Census 2011. Ministry of Home Affairs, Government of India.

Government of India. (2018a). Agriculture Statistics at a Glance. Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.

Government of India. (2018b). Horticulture Statistics 2018. Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.

Hossain, M.A., Hasan, M.K. and Naher, Q. (2008). Assessment of technical efficiency of potato producers in some selected areas of Bangladesh. *Journal of Agriculture & Rural Development*, 6: 113-118.

Jondrow, J., Lovell, C.A.K., Materov, I.S. and Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Economics*, 19: 233-238.

Kadain, M.S., Lotha, N.E., Girish, B.H., Ilangantileke, S., Ortiz, O., Sah, U., Kumar, S., Pandey, S.K. and Dkhor, S. (2010). A baseline study on potato seed production systems in Meghalaya and Nagaland States of Northeast India. International Potato Center, Working Paper, Pp. 1-21.

Khai, Viet Huynh and Yabe, M. (2011). Technical efficiency analysis of rice production in Vietnam. *Journal of the International Society for Southeast Asian Agricultural Sciences*, 17(1): 135-146.

Lal, H. and Sharma, K.D. (2006). Economics of potato production in Lahaul Valley of Himachal Pradesh. *Potato Journal*, 33(3-4): 139-143.

Lama, M. (2018). Agricultural productivity and its determinants in Arunachal Pradesh: an application of Cobb-Douglas type production function. *The NEHU Journal*, 16(2): 61-73.

Lama, M. and Bordoloi, R. (2020). Technical efficiency in potato cultivation in Eastern Himalayas: a case study of Arunachal Pradesh, India. *SSRG International Journal of Agriculture & Environmental Science*, 7(3): 55-63.

Nyagaka, O.D., Obare, G.A., Omiti, J.M. and Nguyo, W. (2010). Technical efficiency in resource use: Evidence from smallholder Irish potato farmers in Nyandarua North district, Kenya. *African Journal of Agricultural Research*, 5(11): 1179-1186.

Pandit, A., Pandey, N.K. Rana, R.K. and Chandran, K.P. (2007). Technical efficiency of Assam Potato Growers. *Potato Journal*, 34: 139-140.

Rana, K. R. and Ejazanwer, Md. (2018). Potato production scenario and analysis of its total factor productivity in India. *Indian Journal of Agricultural Sciences*, 88(9): 1354-61.

Shanmugam, K.R. and Venkatarmani, A. (2006). Technical efficiency in agricultural production and its determinants: an exploratory study at the district level. *Indian Journal of Agricultural Economics*, 61(2): 169-184.

Sharma, R.K., Chauhan, S.K. and Gupta, S. (2008). Technical efficiency in North-Western Himalayan Region: a study of Himachal Pradesh agriculture. *Agricultural Economics Research Review*, 21: 82-90.

Singh, S.K., Tara, S., Singh, K.M. and Kumar, A. (2014). Cultivation and processing of potato in Bihar: issues and strategies. *Environment and Ecology*, 32(4): 1647-1652.

Sujan, H.K., Islam, F., Kazal, M.H. and Mondal, R.K. (2017). Profitability and resource use efficiency of potato cultivation in Munshiganj district of Bangladesh. *SAARC Journal of Agriculture*, 15(2): 193-206.

Udoh, E.J. and Falake, O. (2006). Resource use efficiency and productivity among farmers in Nigeria. *Journal of Agriculture and Social Science*, 2(4): 264-268.

Yadav, S.K. and Srivastava, A.K. (2014). A review on agronomical aspects of potato production in North-eastern region of India. *International Journal of Applied and Pure science and Agriculture*, 1(6): 26-34.

Yamane, T. (1967). Statistics: An Introductory Analysis. 2nd Ed. New York: Harper and Row.