Technical Efficiency of Tuong-Mango by Translog Production Function: Implication for Cooperative and Non-Cooperative Famers in the Southern Vietnam

Truong Hong Vo Tuan Kiet[1*], Nguyen Thi KimThoa[2]

[1]PhD student in Institute of Agricultural and Food Policy Studies, Putra University, Malaysia
[1]SEARCA Scholar, Philippines
[1]Researcher Mekong Delta Development Research Institute, Can Tho University, Vietnam
[2]Mekong Delta Development Research Insitute, Can Tho University, Vietnam

Abstract— *This study employed a Translog stochastic production frontier function to estimate the level of technical efficiency and its determinants among mango farmers in the southern Vietnam. The results of the analysis showed that cropping season of mango growers have been round year. The difference of the study from past researches was efficiency comparison of three seasons instead of only focusing on efficiency of one season or total a year, especially was compared between cooperative and non-cooperative farmer groups. The findings revealed that technical efficiency mean of cooperative farmer category was greater than that of non-cooperative farmer category in season 2. However, technical efficiency mean of cooperative grower group was lower than that of non-cooperative grower group in season 1 and season 3. Results from the study showed that adjustments in the input factors could lead to improved productivity of mango. More so, positive determinants of technical efficiency of cooperative farmer group were land area plant density in three seasons, wrapping bag in season 1 and season 2, education, credit, payment for agro-input wholesale and classifying sale in season 3 while the negative factors were age, credit and payment for agro-input wholesale in season 2. Turning to non-cooperative farmer group, the positive determinants of technical efficiency were land area in three seasons, market access in season 2 and season 3 and payment for agro-input wholesale and wrapping bag in season 2 whereas the negative elements were farming experience in season 1.*

Keywords— Technical efficiency, Tuong-mango, cooperative, the southern Vietnam.

I. INTRODUCTION

Mango is one of the most prevalent tropical fruit in the world, especially is in Asia. Vietnam was mango volume about 836 thousand tons in 2017 [6]. It ranked fourth in terms of mango volume in Southeast Asia after Thailand, Indonesia and Philippines and was top 15 the largest mango producers in the world. In Vietnam, mango has been grown in all provinces of the county (Figure 1), in which in the southern Vietnam has considered center for mango production in Vietnam. The southern Vietnam has provided to international and domestic market about fresh mango 552,000 ton/year with area nearly 51,500 ha [8].

The household survey carried out by [32] that indicated gross income from mango production was reported at an average of 186 million VND per household per year, with net income of 105.4 million VND (US$ 83.65 per person per month at exchange rate of US$1 = VND 21,000 and assuming average household size of 5 members), average household cultivation area of 0.68 ha. Mango cultivation was primarily small farmers activity. Smallholder farmers faced numerous challenges in utilization of available resources which affected their efficiency, productivity, awareness of quality requirements, poor technical skills and difficulties in funding investment.

Therefore, the objective of this study was to isolate the efficiency component in order to measure its contribution to productivity and pay particular attention on determinants of efficiency associated with structural variables that could influence efficiency differentials among production units [13, 17, 29, 31]. This brought in formulating the policy measures to alleviate different constraints in the Tuong-mango production of various Tuong-mango seasons of year in the southern Vietnam. The study specifically found out effective disparities among Tuong-mango seasons of year, the technical relationships between inputs and output in mango production, determinants of technical efficiency in Tuong- mango production.

II. METHODOLOGY

2.1 Sampling Techniques

A multi-stage sampling technique was used to select the study area. Firstly, south-eastern region and Mekong Delta region were purposively selected for the study due to its comparative advantage in mango production system with accounting for 75% volume and making up 72% area in Vietnam. Secondly, Dong Nai province of south-eastern region and Dong Thap, An Giang, Tien Giang, Hau Giang, Vinh Long, and Tra Vinh provinces of Mekong Delta were chosen because Dong Nai province occupied approximately 55% volume and making up 54% area in south-eastern region and six provinces accounted for about 77% volume and making up 71% area in Mekong Delta [8]. Finally, simple random technique was used to select 296sampling observations of cooperative farmer group (100 for season 1; 91 for season 2 and 105 for season 3), and 435sampling observations of non-cooperative farmer group (139 for season 1;158 for season 2 and 138 for season 3).

2.2 Conceptual underpinning

Technical efficiency (TE) was the ability of a farming unit to produce a maximum level of output given a similar level of production inputs, or to produce a given amount of output with minimum inputs [4,17]. Meanwhile, [11] stated that technical inefficiency ascended when actual or observed output from a given input is less than that of the maximum probable. Technical inefficiency reflected deviations from the frontier isoquant [17, 23]. In agricultural field, technical efficiency was capacity of the farmer to produce maximum output frontier production given inputs and technology [22]. The differentials of technical efficiency among farmers could be linked to managerial decisions, environmental conditions (soil quantity, rainfall, temperature, and soil relative humidity), non technical and non economic factors and specific-farm features that could influence the farmers' ability to use technology.

2.3 Empirical Model

The Cobb-Douglas (CD) production function was found to be an adequate representation of the data. The stochastic frontier model was defined by:

$$ln Y_i = \beta o + \beta 1 ln X1 + \beta 2 ln X2 + \beta 3 ln X3 + \beta 4 ln X4 + \beta 5 ln X5 + Vi - Ui$$

The translog production function is alternatively defined as follows:

$$ln\ Yi = \beta o + \beta 1lnX1 + \beta 2lnX2 + \beta 3lnX3 + \beta 4lnX4 + \beta 5lnX5 + 0.5\beta 6(lnX1)^2 + 0.5\beta 7ln(lnX2)^2 + 0.5\beta 8ln(lnX3)^2 + 0.5\beta 9ln(lnX4)^2 + 0.5\beta 10ln(lnX5)^2 + \beta 11lnX1lnX2 + \beta 12lnX1lnX3 + \beta 13lnX1lnX4 + \beta 14\ lnX1lnX5 + \beta 15lnX2lnX3 + \beta 16lnX2lnX4 + \beta 17lnX2lnX5 + \beta 18lnX3lnX4 + \beta 19lnX3lnX5 + \beta 20lnX4lnX5 + Vi - Ui$$

Where:

ln = logarithm to base e

Yi = output of pineapple (kg);

βo = constant or Intercept of the model;

$\beta 1 - \beta 20$ = coefficients to be estimated;

X1 = quantity of pesticide (litres);

X2 = quantity of fungicide (litres);

X3 = quantity of fertilizer_root (kg);

X4 = quantity of fertilizer_leaf (kg) (spraying on mango leaves to stimulate mango flower);

X5 = family and hired labour (man-days);

Vi = random error term;

Ui = technical inefficiency effect predicted by the model and the subscript *i* indicate the i^{th} farmer in the sample.

The determinants of technical efficiency of mango farmers in line with [16] were modelled following specific characteristic of farmers in the study area. From equation the component was specified as following:

$$u_i = \alpha_0 + \sum_{r=1}^{10} \alpha_r Z_r + \mathrm{k}$$

Where:

u_i = technical inefficiency of i-th farmer,

α_0 and α_r = parameters to be estimated,

k = truncated random variable.

Z_1 = Farmer`s age (year),

Z_2 = Level of education (years spent in acquiring formal education)

Z_3 = Farming experience (year)

Z_4 = Credit access (access =1, no access = 0)

Z5 = Payment for agro-input wholesaler (ending of crop =1, payment immediately =0)

Z_6 = Wrapping bag (wrap = 1, no wrap =0)

Z_7 = Market access (access = 1, no access = 0)

Z_8 = Classifying sale (classification =1, no classification = 0)

Z_9 = Plant density (plants/ha)

Z_{10} = Land area (cong = 1,000 m^2)

The estimates for all the parameters of production functions and inefficiency model were obtained by maximizing the likelihood function on the programme FRONTIER 4.1

III. EMPIRICAL RESULTS

3.1 Seasonal Schedule of mango in the southern Vietnam

Nowadays, mango seasons of farmers in the southern Vietnam have been produced actively round year by flowering stimulation technique. This has brought harvesting season of mango to take place all year following as:

Natural season: flowering from January to February, harvesting from middle April to ending June.

Early season: flowering from November to December, harvesting from middle February to April.

Off-season:: flowering from May to June, harvesting from middle August to October.

Late season: flowering form ending August – October, harvesting from ending November to February of next year (it is called festival-season because harvesting time focuses on important festivals such as middle October following Lunar calendar (Buddhist day), Noel, New Year, Lunar New Year and middle January of next year following Lunar calendar (Buddhist day).

TABLE 1
SEASONAL SCHEDULE OF MANGO IN THE SOUTHERN VIETNAM

Months		1	2	3	4	5	6	7	8	9	10	11	12
Sunny season	Natural season	Flower			Harvest								
	Early season		Harvest									Flower	
Rainy season	Off-season					Flower			Harvest				
	Late season	Harvestt							Flower			Harvest	

Source: Field Survey Data, 2018

Although mango producers in the southern Vietnam are able to produce mango round year (Table 1) by flowering stimulation technique on off-season, they usually choose two seasons per year or maximize three seasons per year. Based on weather condition in the southern Vietnam where has sunny season and rainy season, the study divides three main mango seasons in the southern Vietnam. Firstly, **off-season** is considered main season in the southern Vietnam because selling price is often high compared to other seasons (it is called **season 1**). Secondly, **late season** (festival season) is called **season 2** with high selling price but it must be competed strictly with different fruits in the period. Finally, **natural and early season** of sunny season is called **season 3** and it is season to occur in favorable climate condition. Thus, production cost differs from off-season and late season of rainy season.

3.2 Estimation Procedure

To select the lead functional form for the data, hypothesis test base on the generalized likelihood ratio test (LR) was conducted. = - 2 {log [L (H0) – log [L (H1)]} formula was used to carry out the likelihood ratio test. The null hypothesis was the statement that the Cobb-Douglas production function was the best fit for the data. Result indicated that it was rejected the null hypothesis in six cases because lamda values $\boldsymbol{\lambda 1}$=48.12, $\boldsymbol{\lambda 2}$=35.58, $\boldsymbol{\lambda 3}$=65.68, $\boldsymbol{\lambda 4}$=78.22, $\boldsymbol{\lambda 5}$ =40.12, $\boldsymbol{\lambda 6}$= 36.76 were greater than critical value (25.0) at 5% level of significance, meaning that Translog form was the best functional form for the data (Table 2).

TABLE 2
GENERALIZED LIKELIHOOD RATIO TEST FOR STOCHASTIC PRODUCTION MODEL

Season	Null Hypotheses	Log likelihood (H_0)	Log likelihood (H_1)	Test statistic (λ)	Degree of Freedom	Critical value (5%)	Decision
Cooperative							
Season 1	Cobb-Douglas is the best fit	-97.38	-73.32	48.12	15	25	Rejected
Season 2	Cobb-Douglas is the best fit	-99.07	-82.78	32.58	15	25	Rejected
Season 3	Cobb-Douglas is the best fit	-116.10	-83.26	65.68	15	25	Rejected
Non-coop							
Season 1	Cobb-Douglas is the best fit	-140.76	-101.65	78.22	15	25	Rejected
Season 2	Cobb-Douglas is the best fit	-165.55	-145.49	40.12	15	25	Rejected
Season 3	Cobb-Douglas is the best fit	-124.17	-105.79	36.76	15	25	Rejected

Critical values with asterisk are taken from Kodde and Palm (1986). For these variables the statistic λ is distributed following a mixed χ2 distribution

The expected parameters and the related statistical test results obtained from the analysis of the maximum likelihood estimates (MLE) of the Translog based on stochastic frontier production function for Tuong-mango farmers in the southern Vietnam were presented in Table 3. The sigma squares (σ^2) of cooperative farmer category were 0.32 in season 1; 0.91 in season 2; and 0.36 in season 3, and that of non-cooperative farmer category were 0.55 in season 1; 0.44 in season 2; and 0.43 in season 3, which were found to be significantly different from zero, suggested a good fit of the models and the correctness of the specified distributional assumptions respectively.

Furthermore, the gamma parameters of cooperative farmer group (γ_1=0.7688, γ_2=0.9999, γ_3=0.9999) were quite high and significant at 1.0% level of probability, implying that 76.88% of variation in season 1, and 99.99% of variation in season 2 and season 3, which resulted from technical efficiency of the sampled farmers rather than random variability. Similarly, the gamma parameters of non-cooperative farmer group (γ_1=0.9999, γ_2=0.6882, γ_3=0.9999) were significant at 1.0% level. This revealed that there were 99.99%; 68.82% and 99.99% in technical efficiency to be explained by given variables in season 1, season 2 and season 3 respectively.

TABLE 3
MLE ESTIMATES FOR SFA MODEL

Variables	Season 1		Season 2		Season 3	
	Coop	*Non-Coop*	*Coop*	*Non-Coop*	*Coop*	*Non-Coop*
	Coef.	*Coef.*	*Coef.*	*Coef.*	*Coef.*	*Coef.*
Dependend Variable (Y: Ln Yeild(kg))						
Constant	10.244***	3.010***	4.570***	7.212***	9.246***	5.308***
(X_1) Ln pesticide (litres)	1.093*	-0.559***	0.110	0.096	0.893**	-1.124***
(X_2) Ln fungicide (litres)	-0.134	0.710**	-0.329	0.703**	-0.073	0.286
(X_3) Ln fertilizer_root (kg)	-0.997*	-0.454***	-0.246	-0.160	-0.137	-0.062***
(X_4) Ln fertilizer_leaf (kg)	-0.009	0.425	0.577	-0.364	0.134	0.235
(X_5) Ln labour (man day)	0.301	2.224***	1.971***	0.933**	-0.121	2.309***
½ *Ln $(X1)^2$	0.112	-0.136***	-0.095	0.033	0.058	-0.162***
½ *Ln $(X2)^2$	0.201*	0.152***	0.043	-0.025	0.037	0.054
½ *Ln $(X3)^2$	0.099	0.361***	0.006	0.069**	0.067**	0.067***
½ *Ln $(X4)^2$	0.110	0.416***	0.090	0.135	0.033	-0.002
½ *Ln $(X5)^2$	0.017	-0.670***	-1.058***	-0.331*	-0.040	-0.474***
Ln (X1)*Ln(X2)	-0.081	0.106***	-0.036	-0.014	0.003	0.040
Ln (X1)*Ln(X3)	-0.118	0.174***	0.131**	-0.001	-0.083	-0.005
Ln (X1)*Ln(X4)	-0.031	-0.403***	-0.051	0.049	0.120**	0.017
Ln (X1)*Ln(X5)	-0.034	0.221**	-0.017	-0.055	-0.167*	0.334***
Ln (X2)*Ln(X3)	0.043	-0.036	-0.110	-0.037	-0.051	0.076**
Ln (X2)*Ln(X4)	0.073	0.039	0.064	-0.124*	-0.109*	0.044
Ln (X2)*Ln(X5)	-0.213*	-0.313***	0.194	-0.011	0.095	-0.263***
Ln (X3)*Ln(X4)	-0.032	-0.422***	-0.318***	-0.026	-0.017	-0.076**
Ln (X3)*Ln(X5)	0.132	-0.050	0.280***	0.009	0.072*	-0.049**
Ln(X4) *Ln(X5)	-0.033	0.413***	0.211*	0.142	-0.002	0.002
Diagnostic Statistics						
Sigma sqaure (σ^2)	0.3199	0.5521	0.9084	0.4414	0.3626	0.4248
Gamma (γ)	0.7688***	0.9999***	0.9999***	0.6882***	0.9999***	0.9999***
Log-likelihood function	-73.327	-101.656	-82.787	-145.49	-83.269	-105.79
Number of observations (N)	100	139	91	158	105	138

Source: Field Survey Data, 2018
**** Significant at 10% level, ** significant at 5% level, *** significant at 1% level***

Regarding season 1, the analysis of the estimated model of cooperative producer group pointed out that the coefficient of pesticide was positive and statistically significant at 10% level while the coefficient of fertilizer (root) was negative at 10% significant level. The positive relationship of pesticide with yield suggested that a 10% increase in pesticide will result to 10.93% increase in yield of mango farmers. The coefficients of the square term for fungicide was positively and highly significant at 1% levels of probability, showing a direct relationship with yield but the coefficients of interaction between fungicide and labour was negative, indicating increase in the combination will decrease yield of Tuong-mango farmers. Meanwhile, the analysis of the estimated model of non-cooperative producer group revealed that coefficient of fungicide and labour were positive at significant 5%, 1% level respectively whereas the coefficients of pesticide and fertilizer (root) were negative at significant 1% level. The coefficients of the square term for fungicide, fertilizer (root), fertilizer (leaf) and those of interactions between pesticide and fungicide, pesticide and fertilizer (root), pesticide and labour, fertilizer (leaf) and labour were positively significant at the conventional significance levels. This implied that these combinations would bring higher productivity for growers producing Tuong-mango.

Turning to season 2, labour variable of cooperative farmer category were positive and significant at 1% level with coefficient of 1.971. Alternatively a 10% rise in labour will lead to 19.71% growth in yield from Tuong-mango production. However, the coefficients of the square term of labour was negative, showing increase of labour in production was limited to output. Additionally, the coefficient of interaction between pesticide and fertilizer (root), fertilizer (root) and labour, fertilizer (leaf) and labour were positive and significant at 5%, 1% and 10% level respectively, implying that increases in the combinations lead to increases in output of Tuong-mango. Besides, fungicide and labour variables of non-cooperative farmer category were positive and significant at 5% level with coefficient of 0.703 and 0.933. By contrast, the coefficient of interaction between fungicide and fertilizer (leaf) was negatively significant at 10% level of probability, indicating that the more fungicide and fertilizer (leaf), the lower yield of Tuong-mango production.

For season 3, the results also showed that the coefficients of the explanatory variable of pesticide in cooperative grower category were positively significant at 5% level. It meant that a 10% increase in pesticide would result in8.93% increase in productivity of Tuong-mango. Also, the coefficient of the square term for fertilizer (root) and those of interactions between pesticide and fertilizer (leaf), fertilizer (leaf) and labour were positively significant at the conventional significance levels and had a direct relationship with output of Tuong-mango production. For non-cooperative grower category, input variable of labour played important and positive role in impacting on Tuong-mango production with high coefficient of 2.309 at 1% level of significance while pesticide and fertilizer (root) variables were negatively significant at 1% level with coefficient of -1.124 and -0.062. In addition, the coefficient of the square term for pesticide and labour were negative influence on yield of Tuong-mango at 1% significant level where as that of fertilizer (root) affected positively at 1% level. Moreover, the coefficients of interaction between pesticide and labour, fungicide and fertilizer (root) were positively significant at 1% and 5% level of probability contrasting with that of interaction between fungicide and labour, fertilizer (root) and fertilizer (leaf), fertilizer (root) and laour being negative and significant effect on productivity of Tuong-mango at the conventional significance levels.

3.3 Determinants of technical efficiency

The analysis results of Table 4 showed the relationship between technical efficiency and household characteristics.

TABLE 4
MLE OF THE DETERMINANTS OF TECHNICAL INEFFICIENCY

Variables	Season 1		Seaon 2		Season 3	
	Coop	*Non-Coop*	*Coop*	*Non-Coop*	*Coop*	*Non-Coop*
Technical Inefficiency Model	*Coef.*	*Coef.*	*Coef.*	*Coef.*	*Coef.*	*Coef.*
Constant	2.126***	2.121***	0.062	3.302***	3.790***	2.929***
(Z_1) Age	0.008	-0.005	0.034***	0.004	-0.002	-0.002
(Z_2) Education	0.009	-0.015	0.006	0.003	-0.031*	0.011
(Z_3) Farming experience	0.013	0.023*	-0.006	-0.005	-0.004	0.004
(Z_4) Credit	0.113	0.299	0.664**	0.110	-0.409**	-0.053
(Z_5) Payment for agro- input	0.156	-0.090	0.831**	-0.311**	-0.292*	0.061
(Z_6) Wrapping bag	-0.450**	0.250	0.310	-0.405**	-0.238*	0.000
(Z_7) Market access	0.141	-0.159	-0.150	-0.545***	0.054	-0.406**
(Z_8) Classifying sale	-0.084	-0.157	-0.075	0.158	-0.348**	0.027
(Z_9) Plant density	-0.001***	-0.001**	-0.002***	0.000	-0.001*	0.000
(Z_{10}) Land area	-0.091***	-0.185***	-0.090***	-0.187***	-0.067***	-0.220***

Source: Field Survey Data, 2018
**** Significant at 10% level, ** significant at 5% level, *** significant at 1% level***

Note: A negative sign of the parameters in the inefficiency function means that the associated variable has a positive effect on economic efficiency, and vice versa.

In season 1, the coefficients of plant density and land area in both cooperative and non-cooperative farmer profiles were positive and significant. This implied that the variables had a positive influence on technical efficiency among the mango producers sampled. By contrast, coefficient of farming experience in non-cooperative grower category was negative and significant at 10% level. The result was in disagreement with some earlier studies [26, 27, 28]. The studies stated a positive relationship between technical efficiency and farming experience.

In season 2, the coefficient of land area in both cooperative and non-cooperative farmer profiles also was positive and significant at 1% level. Besides, in non-cooperative farmer profile had three variables to affect positively and significantly on technical efficiency comprising market access, payment for agro-input wholesale on ending of havest season and wrapping bag with coefficient of 0.409; 0.292, and 0.238 respectively. Meanwhile, in cooperative farmer profile experienced negative impact of age, credit access and payment for agro-input wholesale at 1%, 1% and 5% level respectively. The finding of age was in conformity with the result of [1, 24, 15, 9]. However, the research was in disagreement with some earlier studies [19, 21]. The result of credit access differed from past studies of [7,9, 11].

In season 3, the parameter estimate pointed out that market access and land area variables of non-cooperative grower profile were positive and significant with technical efficiency at 5% and 1% level, implying that increases in market access and land area will lead to growth in output of Tuong-mango. Particularly, the coefficients of education, credit, payment for agro-input, wrapping bag, classifying sale, plant density and land area in cooperative grower profile were found positive and significant effect on farmers' technical efficiency at the conventional significance levels.

Educational level of the household head showed a positive effect on TE of mango farmers. The result concurred with the study of [3, 9, 10, 11, 12, 14, 20, 28, 30] who found a strong and positive relationship between educational level and efficiency of the farmers. However, the research was in disagreement with some earlier studies [5,18]. Besides, the finding of credit access showed that it is positively significant towards the efficiency level of farmers at 95% confidence. The result was similar with the study of [10, 12]. This was in disagreement with [7, 9, 11] who stated that receiving credit contributed to farmers' technical inefficiency.

Particularly, land area variable was positive and highly significant coefficients among three seasons in both cooperative and non-cooperative farmer groups. Similar findings were obtained by[2, 25, 28]. However, this went against the findings of [9, 24].

3.4 Technical Efficiency Distribution

TABLE 5
EFFICIENCY LEVEL DISTRIBUTION OF TE SCORES

Technical efficiency level	Season 1		Season 2		Season 3	
	Coop	*Non-Coop*	*Coop*	*Non-Coop*	*Coop*	*Non-Coop*
	%	%	%	%	%	%
<0.1	16.00	5.04	12.09	22.78	36.19	21.74
0.1-<0.2	28.00	18.71	18.68	27.22	24.76	26.09
0.2-<0.3	8.00	20.14	13.19	17.09	11.43	11.59
0.3-<0.4	13.00	12.95	9.89	8.86	7.62	15.22
0.4-<0.5	8.00	7.19	12.09	5.06	4.76	6.52
0.5-<0.6	5.00	10.07	3.30	5.06	3.81	5.07
0.6-<0.7	3.00	4.32	7.69	2.53	1.90	1.45
0.7-<0.8	11.00	2.88	9.89	3.80	3.81	1.45
0.8-<0.9	3.00	5.04	2.20	5.70	2.86	2.17
0.9-<1.0	5.00	13.67	10.99	1.90	2.86	8.70
1.0	0.00	0.00	0.00	0.00	0.00	0.00
Number of obs (N)	100	139	91	158	105	138
Minimum	0.0378	0.0355	0.0176	0.0137	0.0175	0.0296
Maximum	0.9398	0.9999	0.9997	0.9307	0.9981	0.9959
Mean	0.3530	0.4387	0.4261	0.2912	0.2489	0.3157
Std.deviation	0.2683	0.2932	0.2960	0.2460	0.2467	0.2750

Source: Field Survey Data, 2018.

Looking at season 1, the analysis of study revealed that technical efficiency ranged from 0.0378-0.9398 with a mean of 0.3530 in cooperative producer category, and from 0.0355-0.9999 with a mean of 0.4387 in non-cooperative producer category. This displayed that the technical efficiency mean of cooperative producer category was lower that of non-cooperative producer category. The result presented big technical efficiency gap of about 64.70% of cooperative producer category, and 56.13% of non-cooperative producer category. This implied that the average farmer in the study area could increase Tuong-mango productivity by 64.70% and 56.13% by improving their technical efficiency. The implication of the result showed that the average mango farmer of cooperative and non-cooperative farmer groups required 62.43% ((1 – 0.3530/0.9398)*100) and 56.12% ((1 – 0.4387/0.9999)*100) respectively cost saving to attain the status of the most efficient mango grower of production, while the least performing of cooperative and non-cooperative farmer groups needed 95.97% ((1 – 0.0378/0.9398)*100) and 96.45% ((1 – 0.0355/0.9999)*100) respectively cost saving to become the least efficient mango grower in the southern Vietnam.

The outstanding feature of season 2 was technical efficiency of cooperative farmer group to achieve between 0.0176 and 0.9997 with the mean technical efficiency of 0.4261 and that of non-cooperative farmer group to acquire from 0.0137 to 0.9307 with the mean technical efficiency of 0.2912. This depicted that the technical efficiency mean of cooperative producer category was greater than that of non-cooperative producer category. The average technical efficiency indexes of 0.4261 and 0.2912 proposed that an average mango farmer of cooperative and non-cooperative farmer groups in the southern Vietnam had the capacity to rise technical efficiency in mango production by 57.39% and 70.88% to obtain the maximum possible level. Thus, the sample frequency distribution indicated that there were efficiency gap but with scope for improvement in mango production among mango farmers. This pointed that average mango farmer of cooperative farmer group and non-cooperative farmer group could experience a cost saving of 57.37% ((1 – 0.4261/0.9997)*100) and 68.71% ((1 – 0.2912/0.9307)*100) respectively whereas the worst efficient farmer of cooperative farmer group and non-cooperative farmer group proposed an improvement in technical efficiency of 98.13% ((1 – 0.0187/0.9997)*100) and 98.53% ((1 – 0.0137/0.9307)*100) respectively.

At the season 3, results also showed that the technical efficiency mean of cooperative grower category (24.89%) was lower than that of non-cooperative grower category (32.57%). The figure indicated that there were efficiency gap but with scope for improvement in mango production among mango farmers. The implication of the result revealed that average mango farmer of cooperative and non-cooperative farmer groups could experience a cost saving of 75.06% ((1 – 0.2489/0.9981)*100) and 67.29% ((1 – 0.3257/0.9959)*100) respectively while the least efficient farmer of cooperative farmer group and non-cooperative farmer group proposed an enhancement in technical efficiency of 98.24% ((1 – 0.0175/0.9981)*100) and 97.02% ((1 – 0.0296/0.9959)*100) respectively.

IV. CONCLUSIONS

The result revealed that technical efficiency mean of cooperative farmer category was greater than that of non-cooperative farmer category in season 2. However, technical efficiency mean of cooperative grower group was lower than that of non-cooperative grower group in season 1 and season 3. Results from the study showed that adjustments in the input factors could lead to improved production of Tuong-mango in the southern Vietnam. In detail, the inputs were important in determining output such as pesticide, fungicide, fertilizer (root) and labour without fertilizer (leaf). Particularly in season 1 and season 3, pesticide variable was positive factor of cooperative farmer group but was negative factor of cooperative farmer group. In season 3, the interaction between pesticed and labour was negative in cooperative farmer category but was positive in non-cooperative farmer category. By contrast, the interaction between fertilizer (root) and labour was positive in cooperative farmer category but was negative in non-cooperative farmer category.

More so, empirical findings indicated that the positive determinants of technical efficiency of cooperative farmer group were land area, plant density in three seasons, wrapping bag in season 1 and season 2, education, credit, payment for agro-input wholesale and classifying sale in season 3 while the negative factors were age, credit and payment for agro-input wholesale in season 2. Turning to non-cooperative farmer group, the positive determinants of technical efficiency were land area in three seasons, market access in season 2 and season 3; and payment for agro-input wholesale and wrapping bag in season 2 whereas the negative elements were farming experience in season 1.

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