TECHNICAL EFFICIENCY AND INCOME LEVEL OF SUGARCANE FARMING IN PATI REGENCY

Efisiensi Teknis dan Tingkat Pendapatan Usaha Tani Tebu di Kabupaten Pati

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Diterima: 6 Desember 2018 Direvisi: 12 Desember 2018 Disetujui terbit: 19 September 2019

ABSTRAK

Defisit produksi gula dalam negeri antara lain disebabkan oleh rendahnya produktivitas usaha tani tebu. Peningkatan efisiensi teknis dapat menjadi solusi untuk meningkatkan produktivitas dan pendapatan petani. Penelitian ini bertujuan untuk menganalisis efisiensi teknis usaha tani tebu dengan metode *MLE stochastic frontier production function.* Data primer diperoleh dari 61 contoh yang dipilih secara acak dari populasi petani tebu di pabrik gula Pakis Baru dan Trangkil di Kabupaten Pati pada April-Mei 2018. Analisis menunjukkan bahwa efisiensi teknis dan pendapatan usaha tani tebu dengan sistem benih baru lebih tinggi daripada dengan sistem kepras. Penggunaan pupuk kimia sudah berlebihan. Keanggotaan kelompok tani berdampak signifikan dalam meningkatkan inefisiensi pada sistem benih baru, sedangkan keanggotaan dalam koperasi berpengaruh signifikan dalam menurunkan inefisiensi pada sistem benih baru. Jumlah anggota keluarga berpengaruh signifikan dalam mengurangi inefisiensi teknis sistem kepras. Efisiensi teknis dan pendapatan usaha tani tebu dapat ditingkatkan melalui optimasi penggunaan sarana produksi dengan mematuhi rekomendasi pabrik mitra dan pemerintah, khususnya penggunaan pupuk sesuai dosis rekomendasi dan penggantian ratun yang sudah berumur tiga tahun dengan benih baru bermutu tinggi sesuai agroekosistem spesifik lokasi. Untuk itu, penyediaan layanan penyuluhan yang efektif merupakan syarat keharusan.

Kata kunci: *efisiensi teknis, inefisiensi teknis, pendapatan, tebu, usahatani*

ABSTRACT

Domestic sugar production deficit is partly caused low productivity of sugarcane farming. Improving technical efficiency may increase farm productivity and income. The study aims to analyze the sugarcane farming technical efficiency by using the stochastic frontier production function. The primary data were obtained from 61 randomly selected samples of sugarcane farmers population of the Pakis Baru and Trangkil sugar factories in Pati Regency in April-May 2018. The study shows that the sugarcane farming technical efficiency and income of the new sugarcane seed system is higher than the ratoon system. Chemical fertilizers have been over used. Farmer group membership significantly increases inefficiency of the new sugarcane seed system, while the cooperative membership significantly decreases inefficiency of the new sugarcane seed system. Family member significantly decreases technical inefficiency of the ratoon system. Technical efficiency and farmers' income can be improved by allocating production inputs in efficient manner based on the recommendations of partner Sugar Factory and Government, of in particular, fertilizer utilizations according to the recommended dosages and replacement of the already three years ratoon seeds with new high-quality seeds in accordance with the local agroecosystem condition. To this end, provision of an effective extension service is imperative.

Keywords: *income, sugarcane farming, technical efficiency, technical innefficiencies*

INTRODUCTION

Indonesia has a potential to be a world sugar producer due to the support of agro-ecosystem, land, and the availability of labor. Ministry of Indus-try has mentioned that the requirement of national sugar in 2017 has reached 5.7 million tons, having a 1.38% decrease from the previous year (Pusdatin Pertanian 2016). The decreasing production and increasing deficit faced by Indonesia are the results of the increasing need for sugar, which not in balance with the improvement of national sugar production. Due to that matter, Indonesia has to import sugar to fulfill the domestic needs of sugar consumption.

The main production centers of sugar cane during 2012−2016 were located in five provinces, namely East Java, Lampung, Central Java, West

Java, and South Sumatera. East Java was in the first rank with 49.14% contribution, while the other regions had under 30% of contribution (Pusdatin Pertanian 2016). The production aspect is one of the most important aspects of a company. The quantity of revenue and profit received by a company depends on how much the related company can produce a product.

Central Java is the second biggest sugar producer in Java Island. Various available potentials to manifest self-sufficiency of sugar in Central Java have not been able to fulfill the consumption needs of sugar for the community, indicated by the deficit of sugar stock in Central Java during 2009−2017 (Tunjungsari 2014). Most of the sugar production in Central Java comes from Pati Regency with a 28% contribution. However, the productivity of sugar cane in Pati Regency was still low, only 4.78 kg/ha, which was below the productivity of sugar cane from the other regencies in Central Java (Pusdatin Pertanian 2016).

In general, the improvement of sugar production can be achieved through the development of the sugarcane area width. However, the availability of sugarcane land becomes limited. Due to that matter, the strategy to develop sugarcane farming has to focus on improving productivity. Some issues also occur in the effort of productivity improvement, including the utilization of production inputs (fertilizer, seed, pesticide, and labor), which not following the recommendation. The improper amount and combination of those production factors have affected the production and the spent cost (Maryanto et al. 2018). If this condition keeps continuing, then the low level of production and the high cost will cause the income level and the well-being of farmers to decrease. As a result, the motivation of farmers to plant sugarcane will fall, causing the local sugar production to decline. This issue is leading to the import of sugar to fulfill the needs of the community.

The efficiency measurement on the utilization of production input is required to acquire the most optimal combination of production inputs. One of the methods that can be implemented to discover the efficiency of the production factor utilization of sugarcane production is by measuring the technical efficiency value. Technical efficiency measures how efficient the farmers in allocating the inputs on a certain level of technology. Thus, the optimal output will be required. Discussing further, to suppress the high import of sugar, the government implements an effort embodied through the acceleration program in which one of them is plant planting new sugarcane seeds. Planting new sugarcane seeds is replacing the old sugarcane plants which have been trimmed at least three times with the new plants. Planting new sugarcane seeds is aimed to improve sugarcane productivity and rendement (sugar content). This effort is made by replacing the old plants with the new, improved variety of plants. These new plants are either originating from seeds produced through plant tissue culturing certified by local UPTD (Regional Technical Implementation Unit) or using the conventional seeds in which the origin has been pre-certificated (Rukmana 2015).

According to the review, the approach suitable to estimate the technical efficiency and inefficiency rate in Pati Regency is the application of a stochastic frontier production function. This model has been widely used to study the technical efficiency of farming, including onion farming (Waryanto et al. 2014), cassava farming (Anggraini et al. 2016), potato farming (Maryanto et al. 2018), and sugarcane farming (Purnamasari and Ar 2018). Discussing further, the studies regarding technical efficiency mostly used the Cobb-Douglas production function. This production function is easy for estimation and interpretation because the parameters are minimized to be in multicollinearity and directly indicating the elasticity value of each production factor or the estimation of returns to scale.

Based on Asyarif and Hanani (2018), the area of sugar cane is around 40% done in wetland and 60% in the dry land. The expansion of sugarcane areas is still constrained by land availability so that the strategy to develop sugar cane farming must focus on increasing productivity. Sugarcane productivity per hectare, which tends to decrease, indicates the inefficiency at the level of sugarcane farming. Fertile land suitable for the development of various agricultural commodities is decreasing from year to year due to competition in land use among various sectors, both agricultural and non-agricultural sectors.

The determining factors of technical inefficiency which have been analyzed in various studies include specific social-economy variables of agriculture, namely age, experience, education, land ownership status, and family size (Yoko et al. 2014) and (Purnamasari and Ar 2018). Socio-economic variables have to be directly combined with the estimation of the production frontier model because those variables might have a direct impact on the production variable.

The inefficiency variables generally used in the previous studies have not been able to illustrate the actual condition in the research location that has obtained numerous interventions from the government. This research uses managerial capability variables, namely the institutional variables such as the participation of farmers in the extension activity, farmer group membership, and cooperative membership. Those variables have an important role in the ability to accumulate information on sugarcane farming. Besides, different from the previous studies, this study compares technical efficiency and income of sugarcane farming planting new sugarcane seed system (ratooning replacement) to those practicing ratooning syatem. This comparison is required considering that 80% of sugarcane farmers remain practicing ratooning system to save production costs, and therefore, the revenue will be higher.

The plantation sector cannot be separated from a partnership. A partnership can provide higher income and profit for farmers and large entrepreneurs (sugar factory) (Pintakami et al. 2013). This is because sugarcane is different from other agricultural commodities. It cannot be sold directly in the form of the crop but requires additional handling in the way of milling to become sugar. In Pati Regency, there are two sugar factories (PG), namely PG Pakis Baru and PG Trangkil. Partnership with PG has an essential role for farmers, namely as the distribution of production and sales facilities for production, capital provision, an extension of farming development, and improvement of input-output prices, so that the partnership system is expected to increase income.

This research is expected to be capable of showing the gap between actual production and potential production that should be received by sugarcane farmers in Pati Regency, especially farmer-partners of PG Pakis Baru and PG Trangkil. Moreover, the research results will be useful for decision making in formulating the policy strategy to achieve the technical efficiency of sugarcane farming. If the realized efficiency rate has been adequately high (approaching frontier), it means that the opportunity to improve further efficiency is not optimistic. On the contrary, if it is still quite low, it means that opportunity is still quite immense to improve efficiency with the existing technology. Allocating minimum input costs at a certain technological level to obtain a certain production level is needed to increase income so that the welfare of sugarcane farmers can be achieved.

According to those research backgrounds, the aims of this research are to (1) estimate the factors which determine the production of sugarcane farming in Pati Regency with planting new sugarcane seeds and ratooning system; (2) analyze the technical efficiency level as well as the factors that cause the technical inefficiency of sugarcane farming in Pati Regency with planting new sugarcane seeds and ratooning system; (3) compare the income levels of the farmers with planting new sugarcane seeds and ratooning system.

RESEARCH METHOD

Conceptual Framework

In this study, the production process is a function of technical efficiency factors that are classified as technical efficiency of sugarcane on the ratooning system and planting new sugarcane seeds system. These factors determine the mix used to optimize sugarcane production. The production itself can determine the income of sugarcane farming on the ratooning system and that on planting new sugarcane seeds system. The inputs in sugarcane production, such as seed, cultivated area, ZA fertilizer, NPK Phonska fertilizer, organic fertilizer, and hired labor, were analyzed in determining the efficiency of available resources for increasing technical efficiency. Factors of inefficiency that determine in production analyzed, such as family size, farmer group membership, land ownership, extension participation, and cooperation member, influence technical inefficiency. All these factors influence the sugarcane farming process at the production to integrate sugarcane and sugar or not to integrate, which in turn will influence the technical efficiency levels and resulting output levels for improving sugarcane farming income and ultimately improving livelihoods. The conceptual framework is presented in Figure 1.

Efficiency concept can be different by three parts such as (1) technical efficiency, (2) price efficiency, and (3) economic efficiency. Technical efficiency is farm ability to obtain optimal level of output from a given bundle of inputs using available technology (Coelli et al. 1998). Technically efficient farming will produce higher output level from the same input use level than other farming.

To determine efficiency analysis using farming factors can be done by comparing actual production to potential production, with formula as follows:

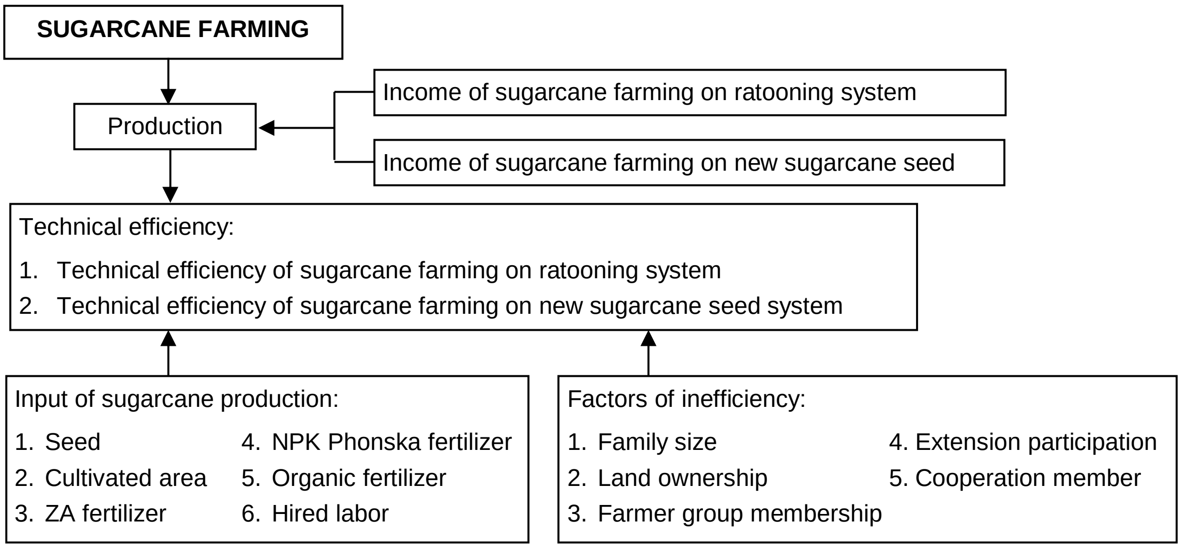
$$TEi = Y/Ya$$

wherever:

TEi = technical efficiency level
Y = potential production
Ya = actual production

Technical efficiency from the farmer can be defined as ratio of actual output to frontier output at the same imput (Saptana et al. 2011):

$$TEi = yi/\exp[f(xi;\beta)] = \exp(-ui)$$



Source: Own conceptualization

Figure 1. Interaction of variables

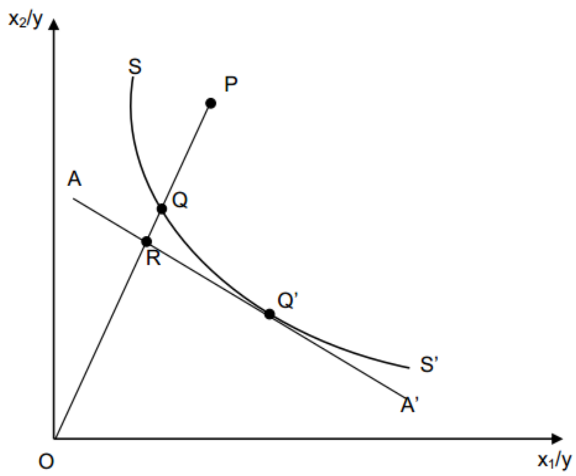
wherever:

- yi = farmer output at-i
- xi = input vector for farmer at-i
- f(.) = Cobb-Douglass function
- β = parameter vector which unknown will be measured
- ui = variable random non-negative related with technical efficiency

TE values range from 0 to 1. If TE value getting closer to 1, then farming can be said to be increasingly technically efficient. If TE value getting closer to 0, then farming can be said to be increasingly technically inefficient. Technical efficiency value inversely related to technical inefficiency effect value and only used for functions that have a certain number of outputs and inputs (cross-section data). The technical efficiency and technical inefficiency are estimated simultaneously using the Frontier 4.1 program (Coelli et al. 1998).

Technical inefficiency refers to deviations from the isoquant frontier. The concept of input side inefficiency is illustrated by Farrell (1957), who is known to be in the position of Constant Return to Scale, as follows: in Figure 2, the SS isoquant frontier curve shows a technically efficient combination of input per output (x^1/y and x^2/y) to produce output $Y_0 = 1$.

Point P and Q describe two conditions of a company in producing output using a combination of inputs with the same proportion (x1/y and x2/y). Both are on the same line from point O to produce one unit Y0. Point P is above the isoquant curve, while point Q indicates that the company operates in technically efficient conditions (because it operates on an isoquant frontier curve). Point Q implies that the company produces the same number of outputs as company P, but with fewer inputs. Thus, the OQ/OP ratio indicates the company technical efficiency (TE) P, which shows the proportion in which the combination of inputs to P can be reduced, the ratio of inputs per output (x1/y and x2/y) is constant, while the output is fixed.



Source: Farrell (1957)

Figure 2. Technical efficiency, allocative efficiency, and economic efficiency

If the input price is available, the allocative efficiency can be determined. The isocost (AA') line is described as offending isoquant (SS') at point Q 'and intersects the OP line at point R. Point R shows the ratio of certain output because the isoquant slope is the same as the isocost line slope. Q point is technically efficient but allocatively inefficient because companies at point Q produce at a higher cost level if they produce at point Q '(allocatively and technically efficient), so that allocative efficiency for companies operating at point P is the OR/OQ ratio.

Data Collection

The research population was the entire sugarcane farmers in Pati Regency, which amounted to 3,358 farmers (Pusdatin Pertanian 2016). This sample location was purposively selected because Pati Regency is the production center of sugarcane in Central Java, and it has specific socioeconomic characteristics of farmers. The primary data were obtained randomly from 61 partner farmers of Pakis Baru and Trangkil sugar factories, which located in Pati Regency. The partner farmers of PG Pakis Baru and PG Trangkil were selected as the sample because the majority of sugarcane farmers in Pati Regency consider the efficiency of transportation cost. Therefore, they entrust the processing and marketing to both factories. The interview was conducted using a questionnaire on sugarcane farming during the planting season of 2017. The study was conducted from April to May 2018.

This research was containing abstract variables that were measured through dummy variables. A dummy variable is a variable used to quantify a qualitative variable, comprising family size, farmer group membership, land ownership, cooperation membership, and extension participation. A dummy variable has two values, namely 1 and 0. Dummy has a value of 1 (D=1) for one category and 0 (D=0) for the other category. The value of 1 usually indicates the group that obtains treatment, and vice versa.

Data Analysis

1. Production

Ordinary Least Square (OLS) method was used to identify factors that influence sugarcane production in Pati Regency, while Frontier production function model allegedly using the Frontier 4.1 application with the MLE (Maximum Likelihood Estimation) (Purnamasari and Ar 2018). The frontier production function represents the maximum production that can be achieved for a number of production inputs that are sacrificed. The original specification includes a production function specified for cross-sectional data, which has an error term consisting of two components: one is caused by random effects (ui), and the other one is caused by technical inefficiency (vi) (Anggraini et al. 2016). The technical efficiency of sugarcane farming is assumed by using the equation formulated by Coelli et al. (1998) as follows:

$$TEi = \frac{Yi}{Yi'} = \frac{\exp(xi\beta + vi - ui)}{\exp(xi\beta + vi)} = \exp(ui) \quad (1)$$

Tei = technical efficiency,
Yi = actual production,
Yi’ = potential production,

TEi values ranged from 0<TE<1. If the value of TEi was closer to one, then a farm was stated to be technically efficient, while if the value of TEi was closer to zero, then the farm was stated to be technically inefficient.The form of the Cobb-Douglas Stochastic Frontier equation is transformed into the natural logarithms (Rofiqoh and Agustina 2018).

The frontier production function for the new seed system is

LnYTB = β_0 + β_1 ln (Seed) + β_2 ln (Planting new sugarcane seeds area) + β_3 ln (ZA) + β_4 ln (NPK Phonska) + β_5 ln (Organic) + β_6 ln (Labor of New Plant) +Vi-ui ....(2)

YTB = production of sugar cane on planting new sugarcane seeds system in (kg),
Seed = amount of seed (qu),
NewSeed = New sugarcane seeds area (Ha),
ZA = amount of ZA fertilizer (kg),
NPK = amount of NPK Phonska fertilizer (kg),
Organic = amount of organic fertilizer (kg),
LaborNP = labor used for new sugarcane seeds system (man days work),
LaborRT = labor used for planting new ratooning seeds system (man days work),
vi = random error,
ui = random variable representing technical inefficiency.

The frontier production fdunction for the new seed system is

LnYK = β_0 + β_1 ln (sulam seed) + $\beta_2$ln (Ratooning area) + $\beta_3$ln (ZA) + $\beta_4$ln (NPK Phonska) + $\beta_5$ln (Organic) + $\beta_6$ln (Labor of ratoon) +Vi-ui..(3)

YK = production of sugarcane on ratooning system in (kg),

*Sulam*seed = replantreds seed (*sulam)* (kg)

Ratooning area = area used (ha),

ZA = the amount of ZA fertilizer (kg),

NPK Phonska = the amount of NPK Phonska fertilizer (kg),

Organic = the amount of organic fertilizer (kg),

Labor of ratooning = number of hired labor ratooning system (man days),

vi = random error,

ui = a random variable that represents the technical inefficiency.

2. Technical Inefficiency

Technical inefficiency factor is determined by another factor beyond the input associated with managerial aspect of farmers. Mathematically, technical inefficiency of sugarcane in Pati Regency (ui) is formulated as follows:

$$u_i = \delta_0 + \delta_1(JAK) + \delta_2(KT) + \delta_3(Kop) + \delta_4(KL) + \delta_5(Ext) + (v_i - u_i) \quad (4)$$

JAK = farmer's family member (person),

KT = dummy farmers group memberships (KT=1 for active farmers (as manager of farmers group membership or member that active to follow farmer group membership meeting regularly, KT=0 for passive member),

Kop = dummy cooperative membership (Kop=1, for active farmer (as manager of cooperative or member that active to follow cooperative agenda), and Kop=0 for passive farmer),

KL = ownership of sugar cane farming land (KL=1 for land self-ownership and KL=0 for land rent-ownership),

Ext = dummy extension participation (Ext=1 for active farmer (farmer that active to follow extension programs regularly and Ext=0 for passive farmer).

3. Income Level

Descriptive analysis was used to find out the income of sugarcane on planting new sugarcane seeds and ratooning system. There are two elements used to measure income level, namely the elements of return and cost. Return is the result of multiplying the total number of products (sugarcane production in kg multiplied by rendement) then multiplied by the unit of sale price, while the expenditure or cost used as the value of the use of production facilities and others issued in the production process. Mathematically to calculate farm income is written as follows:

$$\pi = Y.Py - \sum Xi.Pxi \quad (5)$$

Π = income (Rp),

Y = sugar production (kg),

Py = price of sugar production (Rp/unit),

Xi = a factor of production i = 1.2.3 ... n (kg/unit)

Pxi = price of the i factor of production (Rp/unit).

RESULTS AND DISCUSSION

The decision in using an area in a particular region to be planted with agricultural commodities is determined by various factors. Those factors might include physical or nonphysical factors established on the area: (1) physical factors that affect the possibility of agricultural land use such as a) climate, temperature (hot), and rainfall; b) topography, relief, and rocks; c) soil, nutrient/ fertility, and soil physical properties; d) water, water potential; (2) human factor: a) culture and history, labor/work force, the level of technological skills, and abilities of farmers (education, knowledge, experience, and management), sufficient capability of labors (either family-related or nonfamily labors) (Erviyana 2014). Economic factors which encompass capital, equipment, building, and money; agricultural production supply; the amount of agricultural product demanded by consumers or markets; the input price (production facilities) and the price of agricultural production. In addition, political factors include the participation of farmers in government practices and policies such as prices, taxes, import/export assessment, and others; the prohibition to plant a certain type of plant, for instance, marijuana and others; trading restriction, for instance, only based on the agreed quota; government reliefs such as capital, seeds, fertilizers, etc. (Rattray 2012).

Farmers' Characteristics

The success of farming is highly determined by the characteristics of the farmers as the farming actors, as well as the decision-maker and taker in running farming activities. The characteristics of farmers related to the success of farming mainly include the aspects of age, education level, sex, land ownership, participation in extension, cooperative membership, and farmer group membership.

Formal education indicates the education acquired by farmers in educational institution. According to research results, the highest percentage of education level of sugarcane farmers in Pati Regency was High School graduate (10−12). This result is consistent with the research of Rofiqoh and Agustina (2018) which stated that higher education acquired by farmers would make the farmers to have better mindset and capable of accepting new technology and information required for decision making in relation to the farming activity.

Besides education, the experience of farmers in sugarcane farming is also an important factor in determining the production rate of sugarcane farming. The majority of sugarcane farmers in Pati Regency have performed sugarcane farming for more than 15 years. This condition is consistent with the research of Rofiqoh and Agustina (2018), which indicated that the long experience acquired by farmers in sugarcane farming; thus, farming would be more technically efficient. Decent experience supported by the extension participation that will generate more improvement in production efficiency. According to the research results, 51% of sugarcane farmers were active in extension participation. The extension is held once a month and will be more intensive nearing the harvesting season. The experience and extension participation can influence the capability of farmers in decision making to implement new technology on their farms because it can improve individual knowledge, skills, and proficiency (Maryanto et al. 2018).

The family heads of sugarcane farmers in Pati Regency were mostly categorized in productive age, about 90% of the entire respondents. This condition is consistent with the research of Maryanto et al. (2018), which stated that farmers in productive age are more efficient because they conceive higher capability in performing adaptation and innovation. Therefore, they are more capable of preventing stagnation or a tendency of decreasing productivity due to the degradation of resources. Younger farmers commonly have higher mobility (hence, the opportunity to acquire information is higher) and tend to be more progressive. Most of the family heads of sugarcane farmers were men. This condition indicates that most of the farmers in Pati Regency had strong physical conditions to perform adoption of technology and innovation.

Table 1. Farmer characteristics on new sugarcane planting and ratooning sugarcane, 2018

No.	Criteria	Amount (person)	Percentage
1.	Age (year)		
	15-64	55	90,16%
	>64	6	9,84%
2.	Formal education (year)		
	0 – 6	12	20%
	7 – 9	11	18%
	10 – 12	19	31%
	>12	19	31%
3.	Sugarcane farming experience (year)		
	5	4	7%
	5 up to 10	15	25%
	11 up to 15	6	10%
	>15	36	59%
4.	Family responsibilities		
	0	5	8%
	1	21	34%
	2	12	20%
	3	13	21%
	4	7	11%
	5	2	3%
	>5	1	2%
5.	Farm ownership status		
	Own	40	66%
	Rent	21	34%
6.	Farmer group membership		
	Active	40	66%
	Passive	21	34%
7.	Cooperative membership		
	Active	59	97%
	Passive	2	3%
8.	Extension participation		
	Active	31	51%
	Passive	30	49%

Source: Primary data (2018), processed

Most of the sample farmers (66%) were registered as landowners. The majority of farmers did not produce their own land but instead entrusted the entire cultivation processes to hired labor. Around 62% of farmers had family size of less than three people, which means that the number of the family members that can be empowered to participate in the cultivation process of sugarcane farming was very limited. This condition will increase the technical inefficiency of sugarcane farming because farmers will find difficulty in acquiring labors (Rofiqoh and Agustina 2018).

Problems Faced by Sugarcane Farmers in Pati Regency

The problems faced by sugarcane farmers in Pati Regency and to overcome the problems may ber summarized as follows:

First, the average actual productivity of sugarcane is lower than the average potential productivity of sugarcane on each variety, which being put into the business. This condition occurred on planting new sugarcane seed or the ratooned canes. In the research location, chemical fertilizers were relatively overused. In general, plants cannot absorb 100% of chemical fertilizers. Residues will always be left behind. The residues of chemical fertilizer left within this soil will bind the soil like glue/cement if they are exposed to water. After being dry, the soil will be glued to each other (no longer loose) and becomes hard. Besides getting hard, the soil will also become acidic. These conditions make the nutrient-forming organisms (soil fertilizing organisms) die or decrease in population. Some animals that loosen soil, such as worm, cannot live in the area and lose their natural element. If this happens, the soil will no longer be able to independently provide its food and becomes highly dependent on additional fertilizers (chemical fertilizers) (PT Nongguan 2019). Strategies to improve efficiency are by using the chemical fertilizers based on the government recommendation and combining the use of chemical fertilizers with organic ones to improve the damaged condition of the soil.

Second, sugarcane farmers in Pati Regency generally practice up to four or five times of ratooning due to capital constraints faced by the sugarcane farmers. Ratooning is considered as more efficient because it does not need land and cultivation management. However, according to Rohmah et al. (2016), ratooning which performed more than three times will instead increase the production risk and revenue risk. The strategy to overcome low productions due to excessive ratooning is by replacing the sugarcanes which already having three times of ratooning with planting new seeds. The capital of farmers can be acquired by proposing loan to Sugar Factories or Banks.

Third, the sugar price tends decreasing over time. During the beginning of grinding season, the average price of sugar was Rp.11,000/kg but the price continues to decrease until the end of grinding season which only around Rp.9,600/kg. The strategy to overcome the decrease of sugar price is that farmers have to be wise in determining the variety of sugarcane which will be planted, for instance, by planting more varieties of sugarcane that ripe early or ripe intermediately rather than planting the sugarcanes that ripe at the end. In addition, overall farming operation should be managed properly, starting from the initial loan submission to Sugar Factories, planting, caring, cutting and harvested cane transportation to Sugar Factories. This is especially important to prevent the long queue of hauling.

Fourth, sugarcane farmers in Pati Regency are generally less active in their farmer group. The farmers in Pati Regency only registered their names in farmer group to obtain fertilizer supplies although there are routine counseling activities conducted by the partner sugar factory or the Facilitators of Department of Agriculture who accommodate farmers to receive knowledge regarding the most effective and efficient sugarcane farming. This condition motivates the need of wider socialization toward farmers regarding the importance to be active in farmer organization or field school organized by the related parties.

Fifth, on the side of factories, Pakis Baru Sugar Factory and Trangkil Sugar Factories have frequently experienced technical issues in grinding that jammed the grinding process, and hence lots of sugarcane have been cut down but still cannot be grinded. The juice of sugarcane will be decreasing along with the delay of grinding. This condition will result in decreasing farmers' income.

Sugarcane Production Analysis

In agriculture sector, the physical production is resulted in by the simultaneous run of several production factors, including lands, seeds, fertilizer, pest drugs, and labors (Erviyana 2014). Based on Tables 2 and 3, cultivated area, NPK Phonska fertilizer, and hired labor on planting new sugarcane seeds and ratooning systems have significant impacts on sugarcane. Cultivated areas and hired labor have positive coefficients. It means that increasing the cultivated land and hired labor will increase production. On the contrary, the addition of NPK Phonska fertilizer generates a significant impact on decreasing sugarcane production on planting new sugarcane seeds and ratooning systems of sugarcane. Meanwhile, seeds for planting new sugarcane seeds and seeds for ratooning, ZA, and organic fertilizer on newly revitalized sugarcane and ratooned sugarcane have insignificant impacts on sugarcane production.

Table 2. The Estimation of Sugar Cane Production on Planting New Sugarcane Seeds System Using Ordinary Least Square (OLS)

Variable	Expected	Coefficient		t ratio
Constant	+/-	11.470	***	23.889
Seeds (kg)	+	0.19	Ns	1.436
Cultivater Area of new plant	+	0.931	***	9.997
ZA fertilizer (kg)	+	-0.012	Ns	-0.668
NPK Phonska fertilizer (kg)	+	-0.119	*	-1.918
Organic fertilizer (kg)	+	0.008	Ns	1.441
Hired Labor (man days work)	+	0.137	***	2.178
log likelihood function = -25.90				

Source: Primary Data Analysis (2018)

Description:
* = significant on confidence level of 90% = 1.673
** = significant on confidence level of 95% = 2.004
*** = significant on confidence level of 99% = 2.669

Table 3. The Estimation of Sugar Cane Production on Ratooning System Using Ordinary Least Square (OLS)

Variable	Expected	Coefficient		t ratio
Constant	+/-	11.453	***	25.306
Replantation seeds (kg)	+	0.001	Ns	0.245
Cultivater Area of ratoon cane	+	0.997	***	12.017
ZA fertilizer (kg)	+	-0.005	Ns	-0.264
NPK Phonska fertilizer (kg)	+	-0.112	*	-1.779
Organic fertilizer (kg)	+	0.008	Ns	1.457
Hired Labor (man days work)	+	0.1	*	1.702
log likelihood function = -7.54				

Source: Primary Data Analysis (2018)

Description:
* = significant on confidence level of 90% = 1.673
** = significant on confidence level of 95% = 2.004
*** = significant on confidence level of 99% = 2.669

The average cultivation area of sugarcane with planting new sugarcane seeds system in Pati Regency was 5 ha while the cultivation area of ratooned cane was 15 ha. According to Tables 2 and 3, expanding the cultivation area of new plant and ratooned cane generates a significant impact in increasing the sugarcane production. The regression coefficient of cultivation area of new cultivation/planting new sugarcane seeds system is 0.931, which means that every 1% addition of area width for new cultivation will increase 93.1% of the sugarcane production in new cultivation. Meanwhile, the regression coefficient of the cultivation area for the ratooning system is 0.997, which means that every 1% addition of area width for ratoon cane will increase 99.7% of ratoon cane production. This result is similar to the research of Badmus and Ariyo (2011), Arta et al. (2014), Gultom et al. (2014), and Maryanto et al. (2018), which stated that the improvement of the cultivated area as production input would cause improvement of production. This is because the input utilization will be more efficient if the cultivated area that owned is expanding.

The expansion of the cultivation area in the research site could be performed through land extensification. However, it is not easy to be performed on the actual condition because the majority of land or soil existing in the research location is dry land. This condition is a result of the utilization of wetlands for sugarcane, which is getting more limited due to competition with the other food commodities that have a shorter cultivation period. The limited availability of water will decrease productivity, even in more fertile soil (Tando 2017).

According to research results, the addition of NPK Phonska fertilizer variable has generated a significant impact in decreasing the production of sugarcane. In reference to Table 2, the coefficient regression of NPK Phonska Fertilizer is -0.119, which means that a 1% addition of NPK Phonska fertilizer will reduce 11.9% of sugarcane production on planting new sugarcane seed system. Besides, Table 3 shows that the value of the regression coefficient of NPK Phonska fertilizer is -0.112, which means that every 1% addition of NPK Phonska fertilizer will reduce 11.2% of ratoon cane system production. This result is consistent with Maryanto et al. (2018) which explained that more quantity of NPK Phonska fertilizer would decrease yield, ceteris paribus. This result is contrary to the production theory in which the addition of NPK Phonska fertilizer should have a positive sign. It is assumed that this condition occurs because the production factor was used excessively by farmers. The average usage of NPK Phonska fertilizer is 597.54 kg/ha, while, according to PT Pupuk Indonesia, the recommendation for efficient application of NPK Phonska fertilizer to produce a large diameter of sugarcane stem is 480 kg/ha.

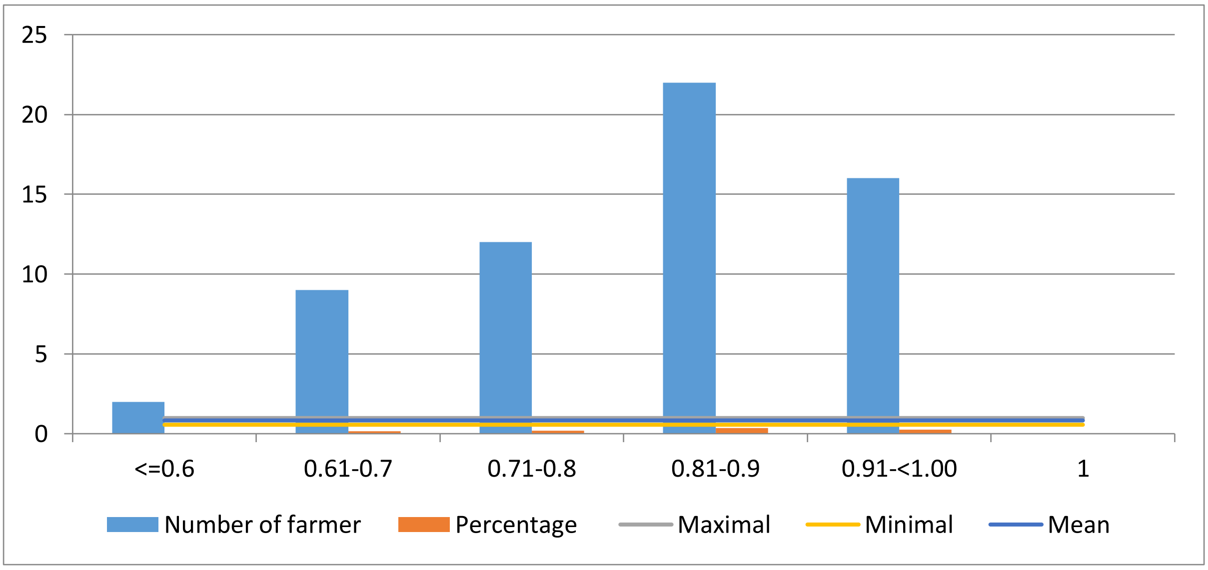
Another variable that has an impact on the production of sugarcane with planting new sugarcane seeds system is the hired labor. According to Table 2, the regression coefficient of hired labor is 0.137, which means that every 1% addition of labor will improve 13.7% of the sugarcane production by planting new sugarcane seeds system. This result is supported by the research of Gultom et al. (2014), which stated that the addition of hired labor would improve the production of sugarcane. The average allocation of hired labor with new planting system is 148 working days. The entire labors employed in the research location are non-relative or do not affiliate to the owner because most of the owners have their primary job besides sugarcane agriculture. Thus, the owners are only acting as the supervisor (not directly involved in the cultivation).

The average need for hired laborers in ratoon cane cultivation is 133 working days. This number is smaller compared to the average labor employed on cultivation by planting new sugarcane seeds system. The ratoon system does not need land processing and seeding staffs. It only needs labor for ratooning. Based on Table 3, the regression coefficient of labor is 0.08, which means that every 1% addition of labor will increase 8% of sugarcane production with ratoon system. Labor is the determining factor, especially for the farm that highly depends on seasons.

In general, the area of ratoon cane reaches 80% of the sugarcane plantation area. The addition of the dummy variable of ratoon cane has generated a significant impact in decreasing the production of sugarcane (Rohmah et al. 2016). Ratooning is ideally performed not more than three years period. The ratooning conducted after the third year will cause productivity to decrease. Thus, land planting new sugarcane seeds is needed.

Technical Efficiency of the New Sugarcane Seeds System

According to Figure 3, the results of the achievement of the technical efficiency of sugarcane farming with planting new sugarcane seeds system can be seen in minimum, maximum, and average manners. The minimum performance of the technical efficiency of sugarcane farming is 0.56, which means that the farmers can only produce 56% of the potential production rate that can be achieved. The maximum achievement of the technical efficiency of sugarcane farming is 0.98, which means that the sugarcane farmers can produce 98.0% of the potential sugarcane production. The average performance of the technical efficiency on sugarcane farming with the planting new sugarcane seeds system is 0.83 or 83% of the maximum production. These conditions indicated that there is a 17% chance for sugarcane



Source: Primary data (2018), processed

Figure 3. Description of statistics for achieving technical efficiency of sugar cane farming for planting new sugarcane seeds system

farmers to reach maximum production. These results also suggest that the average sample of sugarcane farmers with the planting new sugarcane seeds system can be determined as technically inefficient due to 0.83 average value. This condition is consistent with the study of Fahriyah et al. (2018), which showed that the average technical efficiency values of sugarcane farming in wet and dry lands were less than 1, namely 0.9442 and 0.9379, respectively. As an implication, to enhance the efficiency of sugarcane farming, intervention from the government is required. The supports could be in the form of providing prominent seed, agricultural/cultivation techniques, and funding to conduct ratoon replacement/planting new sugarcane seeds.

Based on Table 4, the sigma-squared (σ2) and gamma value (γ) of the estimation through the MLE method are 0.128 and 0.135. The sigma square (σ2) has a value of 0.128, which is greater than 0, which means that the inefficiency effect occurs in the model of sugarcane farming with planting new sugarcane seeds system (Waryanto et al. 2014). The variable of gamma value (γ) is 0.135, which means that 13.5% of error in the production function is caused by technical inefficiency, while the rest 86.5% is caused by random errors.

The value of the LR test using the MLE method amounted to 6.98. The LR test results were then compared with the critical value of X2R with the restriction value of 5 at error rate (2.5%) of 6.031. After comparison, the result of the LR test was greater than the critical value, which means that the coefficient of each variable in the inefficiency effect model affected the level of inefficiency in the sugarcane production process. Besides, the value of the log-likelihood function was -22.41, which is higher than that of the OLS method (-25.90). This indicated that the production function with the MLE method was good and in accordance with field conditions (Gultom et al. 2014).

According to Table 4, the seed variable on planting new sugarcane seeds system has -0.84 coefficient value and significantly influencing at 99% trust level toward the technical efficiency of sugarcane farming. The average utilization of seed by sugarcane farmers in Pati Regency on planting new sugarcane seeds system was 255.16 kg/ha. The majority of seeds used by farmers were local seed variety, namely BL (Bululawang) with 943 Qu/ha potential result of sugarcane and 7.51% of rendement. Besides BL, another sugarcane variety that mostly planted by farmers in Pati Regency were PSJK (Pasuruan Jengkol) and PSJT. This result is contrary to (Arta et al. 2014) and (Yusuf 2015), which stated that the addition of seed quantity would improve production. These results were generated by most of the farmers who used conventional seed without seeds sorting process. Therefore, there were many dead and diverse seeds. The condition of sugarcane variety used shows the composition of imbalance maturities which between early, middle, and later. This condition generates a long grinding process and a high number of ripe sugarcane that are late to be trimmed and processed at the initial/early phase. As a result, the juice will become low (Indrawanto et al. 2010).

According to Table 4, the variable of planting new sugarcane seeds area has 0.055 coefficient value and significantly influencing at a 90% trust level toward the technical efficiency of sugarcane farming. The research results are consistent with the studies conducted by Yusuf (2015), Setyawati

Table 4. The estimation of technical efficiency with planting new sugarcane seeds system using Maximum Likelihood Estimation (MLE)

Variable	Expectation	Coeff		t ratio
Ln Constant		0.10807803E+02	***	0.23826225E+02
Ln New Seed	+	-0.83947660E-06	***	-0.33017554E+01
Ln Planting new sugarcane seeds Area	+	0.55109973E-01	*	0.17956222E+01
Ln ZA fertilizer	+	0.35625416E-07	ns	0.16131961E+00
Ln NPK Phonska fertilizer	+	0.91884534E+00	***	0.71543598E+01
Ln Organik fertilizer	+	0.88500255E-06	***	0.39838006E+01
Ln Hired labor	+	0.23710808E-01	ns	0.50970760E+00
sigma-squared		0.12853510E+00	***	0.36110831E+01
gamma		0.13532996E+00	ns	0.56418051E+00
log likelihood function = -22.41				
LR test of the one-sided error = 6.98				

Source: Primary data (2018), processed

and Wibowo (2016), Rofiqoh et al. (2018), which mentioned that the expansion of cultivation area would enhance the efficiency of sugarcane farming. Setyawati and Wibowo (2016) mentioned that the expansion of the cultivation area would improve the efficiency of sugarcane farming. The width of land is one of the crucial factors in sugarcane farming by considering that the current availability of land is decreasing due to the change of land functions either for housing or industries. In addition, the rent price of land keeps increasing day by day, especially the paddy field. Extensification is prioritized on wetland rather than on the dry land because wetland has better irrigation compared to dry land. The productivity of sugarcane in the wetland amounted to 95 ton/ha, while the productivity of sugarcane in dry land was only 75 tons/ha with 7.5% of rendement (Indrawanto et al. 2010).

Fertilizer is the primary input in agricultural production in the tropics due to a shallow fertility level of humid tropical soils as well as commonly intensive practices of crop production. There are two types of fertilizer in the market, namely organic and inorganic fertilizers (Nugroho et al. 2012).. Inorganic fertilizer is the fertilizer manufactured through chemical, physical, or biological engineering and the industrial output or the product of fertilizer factories. Meanwhile, organic fertilizer is the fertilizer mostly or partially consists of organic materials extracted from plants or animals that have undergone the engineering process. It can be manufactured in solid and liquid forms used to supply organic materials, repair the physical, chemical, and biological properties of soils (Dewanto et al. 2013). Organic fertilizers used by sugarcane farmers in Pati Regency are animal wastes (cows or chickens) and the remains of plants. The availability of organic fertilizers in Pati Regency is still limited. Thus, farmers prefer to use subsidized inorganic fertilizers, namely NPK Phonska and ZA fertilizers. These types of fertilizer used by sugarcane farmers in Pati Regency are consistent with the study of Setyawati and Wibowo (2016) on sugarcane farmers in East Java.

According to Table 4, the utilization of ZA fertilizer showed an insignificant impact on the technical efficiency of sugarcane farming. In contrast, the use of NPK Phonska fertilizer in sugarcane farming on planting new sugarcane seeds system has 0.919 coefficient value and a significant influence at 99% trust level toward the technical efficiency of sugarcane farming. Fertilization is an effort to improve land fertility. It is able to enhance the growth and production of sugarcane with a certain amount and combination. According to the research results, the addition of NPK Phonska fertilizer variable has generated a significant impact on increasing the production of sugarcane.

Currently, the price of chemical (inorganic) fertilizer in Indonesia is continuously increasing due to the increase in fossil energy price as well as the other imported raw materials needed for the production of inorganic fertilizer. The farmers will not afford the high price of inorganic fertilizers unless the government subsidizes it. However, the government budget allocated for fertilizer subsidy will be continuously soaring, which will not be affordable (Nugroho et al. 2012). This condition implies that farmers should combine organic fertilizer with inorganic fertilizer.

Organic fertilizer contributes to improving the physical, chemical, and biological fertilities of soil as well as making the utilization of inorganic fertilizer to be efficient (Hartatik et al. 2015). The regression coefficient of the organic fertilizer variable was 0.00000088, with a 99% significance rate. This condition indicates that the change in the organic fertilizer variable is having an absolute impact on the efficiency of sugarcane farming on planting new sugarcane seeds system. The positive sign indicated that the effect on the change of organic fertilizer variable is directly proportional to the sugarcane production on planting new sugarcane seeds system. The provision of organic fertilizer on sugarcane farming aims to improve the soil structure, improve the absorption of soil toward the water, improve the life condition of microorganism within the soil, stimulate the growth of root, and enhance the plant production as maximum as possible (Rofiqoh et al. 2018).

Technical Inefficiency of the New Sugarcane Seed System

Factors that determine the technical efficiency rate of respondent farmers are measured through the inefficiency effect model of the stochastic frontier production function. The inefficiency estimation results are the simultaneous results acquired along with the production function through the application of the Cobb-Douglas model with the MLE method.

Based on Table 5, the factors that generate significant impact in decreasing technical inefficiency on planting new sugarcane seeds system include dummy farmer group membership and dummy extension of participation, while the number of family member, dummy membership in cooperative, dummy participation in extension, and dummy land ownership status have no significant effect in technical inefficiency.

According to Table 5, the variable of farmer group membership generates a significant impact

Table 5. Estimation of sugarcane farming technical inefficient on planting new sugarcane seeds system in Pati Regency by using Stochastic Frontier production function

Variable	Expected	Coeff		t ratio
Constant	-	-0.41269357E-06	***	-0.10949399E+01
Family member	-	-0.41269357E-06	Ns	-0.10949399E+01
Farmer group membership	-	0.10993643E+00	*	0.17934703E+01
Land ownership	-	0.54939792E-06	Ns	0.10817036E+01
Cooperation	-	-0.94782881E-01	**	-0.13486433E+01
Extension partisipation	-	0.15689652E-05	Ns	0.97142454E+00

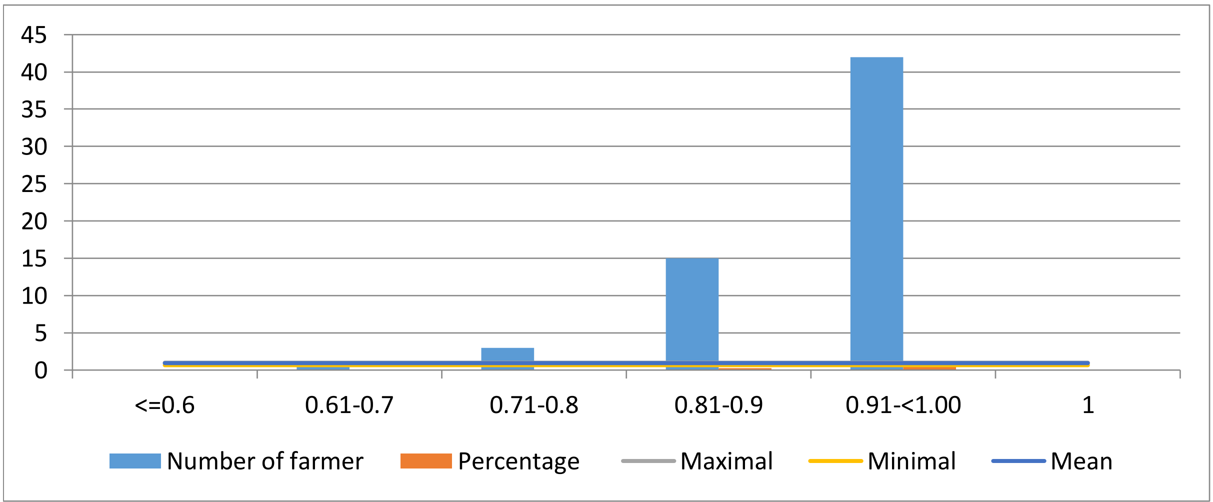
Source: Primary data (2018), processed

on the technical inefficiency of sugarcane farming at a 90% trust level with a coefficient value of 0.11. In general, the farmer group is a communication media among farmers to achieve a business purpose, namely maximum production. The farmer group membership activity is required for the farmers to obtain information related to the technology of plant production, marketing the yields, and overcoming various agricultural issues. By becoming a member of a farmer group, the farmer is entitled to receiving subsidized fertilizers, in which the farmer group proposes an RDKK (Definitive Plan of Farmer Group Necessity). However, the research results are contradicting to the hypothesis that the involvement of farmers in the farmer group will reduce inefficiency. The result of the study of Susilowati and Tinaprilla (2012) described that participation in farmer groups would improve inefficiency because, in reality, more farmers are not active members of farmer groups. In addition, involvement as a member of the farmer group is merely a status; which not actively involved in the group as it should be.

According to Table 5, the variable of cooperative generates a significant impact on the technical inefficiency of sugarcane farming at a 95% trust level with the cooperative coefficient value of -0.094. In general, the function and role of cooperatives in sugarcane farming are to empower farmers through the activities of farmers in the cultivation of sugarcane (on-farm), facilitate farmers in training, procurement of capital, inputs, and things needed in supporting the cultivation and marketing of sugarcane to achieve production efficiency.

Technical Efficiency of the Ratooning System

According to Figure 4, the minimum technical efficiency of sugarcane farming on the ratoon cane system is 0.65, which means that the farmers are capable of producing 65% of sugarcane from the total potential production that can be achieved. The maximum achievement of the technical efficiency of sugarcane farming is 0.99, which means that the farmers can produce 99% sugarcane of the potential sugarcane production that



Source: Primary data (2018), processed

Figure 4. Description of statistics for achieving technical efficiency of sugarcane farming for ratooning system

can be achieved. The average efficiency achievement for ratoon cane farming is 0.93, or 93% of the maximum production. This condition shows that there is still an opportunity for sugarcane farmers to improve 7% of production to reach maximum output. This condition also indicates that the average sample of sugarcane farmers in the ratoon system has been determined as technically inefficient due to 0.93 of value. This result is consistent with the study of Setyawati and Wibowo (2016) which mentioned that sugarcane farming with a ratoon cane system in East Java has not been efficient with 0.89 (<1) of average technical efficiency value.

The results of the stochastic frontier production function on sugarcane on the ratooning system show that the factors that are suspected, together affect production by 99.8%. Based on Table 6, the sigma-squared value (σ2) is 0.073. On sigma square with 0.073 of value, which is greater than 0, there is an inefficiency effect on the sugarcane farming model of the ratoon cane system. The variable of gamma value is 0.072, which shows that there is 7.2% of error in the production function, causing technical inefficiency. Random errors cause the rest 92.8% of the variable. The value of the log-likelihood function is -5.06, which is higher than that of the OLS method (-7.54). This indicates that the production function with the MLE method is good and following field conditions (Gultom et al. 2014).

Factors that generate significant impact on technical efficiency include *sulam* seed and NPK Phonska fertilizer, while the other variables have no significant effect. According to Table 6, *sulam* seed on the ratooning system has a -0.000028 coefficient value and significantly influencing at 99% trust level on the technical efficiency of sugarcane farming on the ratooning system.

The utilization of fertilizer on sugarcane cultivation has led to the balanced use of fertilizers, namely N, P, and K. The role of NPK Phonska fertilizer on sugarcane plan is for the growing process of seed, stem maturity, and development of root besides functioning as the support for the acidity and the alkaline in plant cells. The use of NPK Phonska fertilizer in sugarcane farming on the rationing system has a 0.865 coefficient value and significantly influencing at a 99% trust level towards the technical efficiency of sugarcane farming. It was proven by the research of Setyawati and Wibowo (2016).

Technical Inefficiency of the New Sugarcane Seed Syustem

Factors that determine the technical efficiency rate of respondent farmers are measured through the inefficiency effect model of the stochastic frontier production function. The inefficiency estimation results are the simultaneous results acquired along with the production function through the application of the Cobb-Douglas model with the MLE method.

Based on Table 7, the factor that generates a significant impact on decreasing technical inefficiency is family size. At the same time, the dummy of farmer group membership, the dummy of cooperative membership, the dummy of extension participation, and the dummy of land ownership status have no significant effect on the technical inefficiency of the ratooning system.

The number of family members is correlated with the factor of labor in the production process of sugarcane farming. The research results of Rofiqoh and Agustina (2018) indicated that bigger family size could decrease technical inefficiency. It is because more family members will generate

Table 6. The estimation of technical efficiency on ratooning system using Maximum Likelihood Estimation (MLE)

Variable	Expected	Coeff		t ratio
Ln Constant		0.11061686E+02	***	0.50542760E+02
Ln Sulam seed	+	-0.28095252E-05	***	-0.48748818E+01
Ln Ratooning area	+	0.14793006E-01	ns	0.11234915E+01
Ln ZA fertilizer	+	0.18148517E-07	ns	0.13044185E+00
Ln NPK Phonska fertilizer	+	0.86540315E+00	***	0.14897144E+02
Ln Organik fertilizer	+	0.10388613E-06	ns	0.53114175E+00
Ln Hired labor	+	0.45806255E-01	ns	0.12887790E+01
sigma-squared		0.73108231E-01	*	0.16253170E+01
gamma		0.72416863E-01	ns	0.17249550E+00
log likelihood function = -0.56				
LR test of the one-sided error = 4.96				

Source: Primary data (2018), processed

Table 7. Estimation of sugar cane farming technical inefficient on ratooning system in Pati Regency by using Stochastic Frontier production function

Variable	Expected	Coeff		t ratio
Constant	-	0.37171695E+00	Ns	0.64194558E+00
Family member	-	-0.70629723E-06	*	-0.20829399E+01
Farmer group membership	-	-0.27058687E-01	Ns	-0.44913866E+00
Land ownership	-	-0.92689923E-07	Ns	-0.30125194E+00
Cooperation	-	-0.96313304E-02	Ns	-0.19999079E+00
Extension participation	-	0.42208661E-06	Ns	0.72736412E+00

Source: Primary data (2018), processed

additional support for the farmer in farming. The more the number of family members that contribute to sugarcane farming, the more the requirement of labor in farming fulfilled. Therefore, the supervision toward production will be more intensive.

Farmer Partnership with Sugar Factory

The problem of sugarcane farming and increasing sugarcane efficiency often faced by PG is synchronizing the grinding capacity of the machine with the amount of sugarcane to be ground. The partnership between farmers and PG starts at the beginning of the planting season. Farmers who want to partner with PG, ask permission to PG to become partners. After that, PG assigns its employees to check and map the land with a Global Positioning System (GPS) tool. If the farmers meet the requirements, they will get a number to do sugarcane milling. Then the two parties agree on how many quintals of sugarcane will be milled in PG with loans in the form of fertilizers, cultivation costs, and cutting costs. Capital assistance is obtained from PG in collaboration with a government bank, namely Bank Rakyat Indonesia (BRI). In addition to getting a loan, farmers will also get guidance from PG through its field officers. Coaching is carried out if there are complaints from farmers about sugarcane cultivation. During the grinding season, the farmer will notify PG officers when the sugarcane is ready to harvest and, at the same time, request a Transport Order (SPA) for them to be able to deliver sugarcane to PG. Without the SPA, the farmers cannot deliver their sugarcane to PG. In the SPA, there is a farmer's number and the amount of sugarcane that will be delivered by the farmers to the PG, with a barcode, so farmers cannot falsify the SPA. After that, the farmer can supply sugarcane to the factory and get a sugar note containing the amount of sugarcane deposited, the rendement obtained, and the loan discount and interest. The profit-sharing is set at 66% for farmers and 34% for PG, adjusted to the rendement of sugarcane.

Income Analysis

Sugarcane cultivation in Pati Regency consists of planting new sugarcane seeds and ratooning system. The results of the calculation of income and the comparison of the costs of sugarcane farming in Pati Regency can be seen in Table 8.

The success of sugarcane farming by farmers can be seen from the analysis of farming income. Sugarcane harvesting is usually done from May to

Table 8. Average income and cost of sugar cane farming in Pati Regency

No.	Indicator	Planting new sugarcane seeds system	Ratooning system
1.	RETURN OF SUGAR	61,166,051	49,608,114
2.	TOTAL COST (3+4)	29,955,848	23,397,203
3.	FIX COST	9,239,869	3,224,984
	a. Cost of depreciation	0	0
	b. Land rent and tax	9,239,869	3,224,984
4.	VARIABLE COST	20,715,979	20,172,219
	a. Saprodi cost	5,788,571	2,632,747
	b. Hired labor cost	16,425,263	16,121,438
5.	REVENU (1-2)	31,210,203	26,210,911
6.	R/C Ratio	2.04	2.12

Source: Primary data (2018), processed

September in which the sugarcane is on its optimum condition with the highest juice conten in the dry season. The time of harvesting sugarcane highly depends on the variety of the cultivated sugarcane (early, middle, or late stage of cultivation). In general, the costs required from the cultivation into the harvesting stage is higher on planting new sugarcane seeds/new cultivation system compared to those for ratooning system due to the costs of land processing and procurement of new seeds in the planting new sugarcane seeds system. However, the production of planting new sugarcane seeds system will be better than the production of ratoon cane over three years. Therefore, the revenue of farmers on planting new sugarcane seeds system is higher than the revenue of farmers on ratoon cane. This condition is consistent with the study of Indrawanto et al. (2010) which mentioned that the revenue rate acquired on the third ratooning would decrease to only half of the sugarcane farming profit on the planting new seeds system. This condition emerges because planting new sugarcane seeds is slightly heavier than ratoon cane due to the layout of the cultivation area, the topography or the structure of land is still imperfect. In addition, there are remains or stem/root which disrupt the implementation of the farming. Thus, farmers need higher expenses for labor allocation.

The comparison of total revenues with total costs (R/C ratio) for planting new sugarcane seeds is 2.04, while the R/C ratio for ratoon cane is 2.12, which means that the sugarcane farming in Pati Regency is still profitable (R/C>1). The R/C ratio of ratoon cane is higher than planting new sugarcane seeds. Rohmah et al. (2016) conducted similar research and showed that the first ratooned sugarcanes have a lower risk of revenue compared to planting new sugarcane seeds. However, the second ratooning and so on will keep decreasing the revenue.

CONCLUSION AND RECOMMENDATION

Conclusion

The cultivation area and the labor utilization have significant impact on sugarcane production of both new seeds and ratooning planting systems. NPK fertilizer has significant impact in reducing the production on sugarcane farming in planting new sugarcane seeds and ratooning systems due to over utilization. Farmers income of those planting the new sugarcane seeds system is higher than those planting the ratooning seed system. But, the average technical efficiency of sugarcane faming using new seed systems was only 0.83, lower than those using ratoon seed systems which reached 0.93. Increasing technical efficiency, particularly of those using new seed systems could increase both sugarcane production and farmers' income.

For the new sugarcane seeds system, technical efficiency of sugarcane farming with is positively affected by seed quantity, cultivation area, NPK Phonska fertilizer, and organic fertilizer and farmer group membership, whereas technical inefficiency is negatively affected by cooperative membership and positively affected by farmers' group membership. For the ratoon seeds system, the technical efficiency is positively affected by NPK Phonska fertilizer, whereas technical inefficiency is negatively affected by number of family members.

Recommendation

The study shows that sugar cane farming in Pati Regency has not been technically efficient, particularly those of planting new seed which produces the higher cane production and farmer's income. Chemical fertilizers have been over used. This indicate a room of opportunity for increasing both sugar production and farmers' welfare. Accordingly, the study recommends that the improvement of production and efficiency values can be done by allocating the production input in efficient manner based on the recommendations of partner Sugar Factory and Government, in particular, fertilizers utilization according to the recommended dosage and replacement of the already 3 years ratoon seed with new high quality seed in accordance with the local agroecosystem condition. Policy support that in order to decrease technical inefficiency can be done through regular extension by involving all members of the farmer group and holding field schools to provide information about the most efficient sugar cane cultivation and the important of being cooperative member to facilitate obtaining subsidies and market certainty. Furthermore empowerment of family members as farm laborer is needed to smooth out each and every cultivation process in order to obtain optimal sugar cane production.

ACKNOWLEDGEMENT

We would like to thank the Head of the Department of Agricultural Socio-Economics for assisting the implementation of this research. I would also like to thank my parents for the financial support of the study and my lecturer for constructive criticism and advice of my journal. Thanks are also given to all respondents who were involved in this study.

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