THE EFFECTIVENESS OF THE PRODUCTION OF HEALTHY RICE IN COMPARISON WITH OTHER RICE VARIETIES IN THE UPPER NORTHERN REGION OF THAILAND

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ABSTRACT

The objective of this study is to examine the efficiency of the production of healthy rice and that of other varieties grown in the upper northern region, by using Meta-Frontier approach in analyzing the rice production efficiency. This study focuses on rice production of farmers by comparing between healthy rice growers and farmers of other rice varieties about 300 and 900 sampling respectively, in the areas of Chiang Mai, Chiang Rai and Phayao. In analyzing the efficiency used one variable of the output, the quantity of rice products and five input variables namely quantity of seeds, cost of soil nourishment fertilizer, cost of weeding, cost of labor in production, and cost of labor for harvesting. The study found that there were more variables for analyzing the efficiency of other rice varieties of rice than those of the healthy rice. Plus, general rice growers had higher production efficiency than healthy rice farmers (0.9439 > 0.8604). However, it seems that they should reduce more production factors, particularly labor in production and that in harvesting. Meanwhile, the overall economy of scale had increased while that of each group appeared to be unchanged.

Contribution/Originality: This study is one of very few studies which have examined the efficiency of the production of healthy rice and that of other varieties grown in the upper northern region, by using Meta-Frontier approach in analyzing the rice production efficiency.

1. INTRODUCTION

Rice is an important economic crop of Thailand. In the 2014/15 crop year, there were 60.79 million rais of rice cultivation throughout the country. The total yield of rice paddy was 26.27 million tons. In 2015, Thailand exported 9.795 million tons of rice to foreign countries, making 155,912 million baht (Department of Foreign Trade, 2016). That is, rice is produced for not only domestic consumption, but also export that makes a lot of income each year for the country. Nonetheless, it is worth noting that rice farmers have faced loss due to the increase of production costs and the uncertainty income. A large number of farmers, as a consequence, turn to other jobs. That tends to cause a decrease in rice growing area in the country.

Even though healthy rice is becoming more in-demand as rice consumers are increasingly concerned more about their health and the environment, jasmine rice is still the most marketable domestically and in foreign countries (Office of Agricultural Economics, 2014). Most of the area for healthy rice cultivation, 80%, is in the northeastern region and another 20% is in the northern region. Besides, the area of healthy rice cultivation
decreased, in 2011, by 0.14 million rais, and by 0.12 and 0.11 million rais in 2012 and 2013 respectively (OAE, 2014). Undoubtedly, the price of healthy rice has increased corresponding to the higher demand. The price of organic paddy is 10% higher than that of general paddy. And, the price of organic rice packed in bags is 20% higher than that of general rice, while the price of healthy rice bagged in foreign countries is 25-30% higher than that of general rice (Kasikorn Research Center, 2013).

The situation, in which the amount of organic rice produced does not seem to meet the demand, has raised a question why rice farmers did not choose to produce more organic rice which had been in relatively high demand. One of the sensible causes might be the inefficiency in the production of healthy rice or the lower return compared to that from the production of other varieties. Therefore, they did not have the motivation to produce organic rice. Due to these reasons, it is interesting to study the efficiency of healthy rice production compared with the production of other varieties of rice.

2. REVIEW OF LITERATURE AND RELATED THEORIES

2.1. Performance Measurement Concept

Production efficiency studies have expanded rapidly in the 20th century (Berger and Humphrey, 1997). Estimates of both efficiency and inefficiency rely on many tools such as Stochastic Frontier Analysis (SFA), X-efficiency theory, and Data Envelopment analysis (DEA). Parametric analysis using DEA does not require the selection of frontier function models, but the linear combination, between the groups of production inputs and the corresponding outputs which will encircle the data of the entire sample groups, is adopted. Subsequently, misspecification will not occur. In addition, DEA analysis is a linear programming method for an accurate frontier estimation consistent with the production possibility frontier (Charnes et al., 1995). It is also quite flexible in terms of the production inputs which may have different measurement units or characteristics. Only one value of production efficiency will be obtained (Stanton, 2002). An interesting feature of this method is that it allows comparison of production inputs that are different in the production process. Moreover, the simple concept of the DEA approach in mathematics is that the efficiency of the decision-making unit (DMU) uses n different inputs to obtain m outputs, which are measured in the form of the ratio of weighted outputs per weighted inputs. Additionally, the technical efficiency value obtained must be between 0 and 1. The DEA equation must apply constant returns to scale (CRS) or variable yield to scale (VRS). The concept of DEA created from one input and one output is shown in the Figure 1.

![DEA frontier](https://via.placeholder.com/150)

**Figure 1.** DEA frontier.

Source: Stanton (2002).
Production can be demonstrated via the relationship, between production inputs and production outputs, called Production Function, which shows the amount of product varying according to the inputs used in the production. In determining returns to scale, the effect of changes in all factors simultaneously will be analyzed to see how they affect the amount of product.

1) When the proportion of the increase in all factors is equal to the proportion of the increase in the product, it is considered constant returns to scale (CRS). To clarify, if doubling the amount of all inputs at the same time also double the amount of product, it means that returns to scale is constant.

2) When the proportion of the increase in product is greater than the increase in all production inputs, it is regarded increasing returns to scale (IRS).

3) When the yield increases less than the proportion of the increase in all production inputs, it is considered decreasing returns to scale (DRS).

3. STUDIES ON PRODUCTION EFFICIENCY

There are several of studies on production efficiency using various methods of analysis. Some of the most popular method used by researchers are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). Toshiyuki (1999) examined the ranking test of non-parametric analysis employing DEA, and also studied index measurement with DEA slack adjustment and the application for cooperation in Japanese agriculture. In addition, Toshiyuki and Mika (2001) studied DEA slack adjustment to analyze time series data by examining technical efficiency of Japanese electric power industry during the years 1984-1993. Moreover, Palee (2012) conducted the analysis of technical performance of glutinous rice production in Hang Dong District and San Pa Tong District, Chiangmai Province, with the application of stochastic production frontier. Also, Jutarat (2002) studied technical performance of soybean production in the rainwater area of the lower northern part of Thailand by adopting stochastic production frontier in the analysis as well, to determine the technical productivity of farmers and study the relationship between yield per rai of farmers and various production inputs. Furthermore, Arayaratanakun (2003) applied the stochastic production frontier model and used maximum likelihood estimation method to study technical efficiency of the production of cut orchid flowers.

The production efficiency of agricultural households depends on the following factors.

1) Household characteristics, ages and numbers of household members (Ajibefun et al., 1996; Coelli and Battese, 1996) and levels of education of agricultural household members have a positive effect on the production efficiency of agricultural households (Seyoum et al., 1998; Helfand, 2003; Omononona et al., 2010; Saima et al., 2010). Nevertheless, there are arguments from Bates and Flordeliza (2010) claiming that levels of education has no effect on household productivity. Last but not least, household size (Battese et al., 1996; Nyemeck et al., 2001) and long agricultural experience have a positive effect on production efficiency (Ben, 2000).

2) Having a large agricultural area seems to help increase production efficiency and returns to scale (Jabbar and Akter, 2008; Saima et al., 2010). However, if households divide their land and reduce the cultivating area, that will cause the lack of production efficiency due to waste of production inputs. Besides, the location of farms, specifically the distance between residence and farms and the distance between residence and distribution areas, has a negative effect on production performance (Lyubov and Jensen, 1998; Bates and Flordeliza, 2010). Additionally, it was stated that using labor suitable for production could increase production efficiency (Ajibefun et al., 1996; Lyubov and Jensen, 1998; Bates and Flordeliza, 2010) whereas, moving to work in cities had a negative effect on production efficiency of agricultural households (Joel, 2005).

3) If farmers have formed a cooperative group or agricultural group with funding in the community (Omononona et al., 2010) and have access to loans for production in the community (Joel, 2005; Saima et al., 2010) or have been educated to increase their production experience (Omononona et al., 2010) their household productivity will increase as well.
3.1. Objective
To determine the efficiency of healthy rice production and other varieties of rice mostly grown in the upper northern region of Thailand.

3.2. Research Framework
This study focuses on rice production of farmers by comparing between healthy rice growers and farmers of other rice varieties in the areas of Chiang Mai, Chiang Rai and Phayao, as the top three rice growing areas in the upper northern region of Thailand.

3.3. Research Methods
Step 1 Determine the production efficiency of farmers' households (TEF):
Production efficiency of farmers' households is analyzed by using the non-parametric model based on DEA (Coelli, 1998). The analysis of household production efficiency will be output-oriented, as farmers have to produce the highest amount of production under limited production factors, with the following models.

\[ Z = \sum_{r=1}^{s} \mu_r y_{rj} \]
\[ x_{ij} = \text{input i of household j} \]
\[ \mu_i = \text{weighted value of input i when i = 1, 2, ..., m} \]

Step 2 Identify the rice production efficiency of the farmers (TEF) by classifying the efficiency into 5 levels

| Level of efficiency | Meaning          |
|---------------------|------------------|
| 0.8001-1.0000       | Highest efficiency|
| 0.6001-0.8000       | High efficiency  |
| 0.4001-0.6000       | Medium efficiency|
| 0.2001-0.4000       | Low efficiency   |
| 0.0000-0.2000       | Lowest efficiency|

Source: Cheamnangpham et al. (2013).

4. RESEARCH RESULTS

4.1. Data Used in the Study
In analyzing the efficiency of healthy rice production and general rice production, one variable of the output, the quantity of rice products \((Y_1)\) was used. It was found that the average amount of general rice produced was 35,000 kilograms, the highest, while the lowest yield was 1,200 kilograms. The average quantity was 6,993.47 kilograms. For organic rice, the highest yield amounted to 13,440 kilograms, while the lowest yield totaled 620 kilograms. The average quantity of yield was 4,297.57 kilograms. The study also used five variables, namely quantity of seeds \((X_1)\), cost of soil nourishment fertilizer \((X_2)\), cost of weeding \((X_3)\), cost of labor in production \((X_4)\), and cost of labor for harvesting \((X_5)\).

The highest amount of seeds used was 360 kilograms, which was the amount used by general rice farmers, while the lowest quantity of seeds used was 7 kilograms, used by organic rice growers. The average seed quantity equaled 78.46 kilograms. Plus, by considering the cost of soil nourishment fertilizer \((X_2)\), the highest cost was up to 34,000 baht. However, some organic rice farmers had not used soil fertilizers. That caused the average soil fertilizer cost to be equal to 4,055.65 baht. Moreover, the highest cost of weeding \((X_3)\) amounted to 8,720 baht. Some general rice growers and organic rice growers did not face such cost. That resulted in an average soil fertilizer cost of 307.32 baht. When considering the labor cost of production \((X_4)\), it was revealed that the highest value was 78,400 baht and the lowest cost totaled 400 baht, resulting in an average labor cost of production equal to 5,196.57 baht. Meanwhile, the highest labor cost of harvesting \((X_5)\) amounted to 7,810 baht. The minimum use was 500 baht. This made the average labor cost of production equal to 1,772.28 baht.
4.2. The Efficiency Level of Rice Production

Based on the analysis of rice production efficiency between rice, the general rice production appeared to be more effective than the healthy rice production, as proved by the average of the technical efficiency (TE) of general rice production of 0.9439, whereas the average technical efficiency (TE) of the healthy rice production equaled to 0.8604. Most farmers of each type of rice cultivation had the highest level of efficiency, followed by the high and the medium level respectively as in Table 2. Since 10 farmers, representing 3.33 percent of the healthy rice farmers, had low production efficiency, the overall level of the healthy rice production efficiency turned to be lower than the general rice production. However, when analyzing the production efficiency of both groups of farmers altogether, it was found that the overall production efficiency was at the highest level with the average TE equal to 0.9072.

Table 2. Level of efficiency.

| Level of Eff. | Meaning | General Rice | Healthy Rice | Total |
|---------------|---------|--------------|--------------|-------|
| 0.8001-1.0000 | Highest | 552 | 92.00 | 0.9644 | 224 | 74.67 | 0.9405 | 759 | 84.33 | 0.9603 |
| 0.6001-0.8000 | High | 44 | 7.33 | 0.7178 | -- | 14.67 | 0.6932 | 87 | 9.67 | 0.7053 |
| 0.4001-0.6000 | Medium | 6 | 0.67 | 0.5980 | 22 | 7.33 | 0.5310 | 42 | 4.67 | 0.5376 |
| 0.2001-0.4000 | Low | -- | -- | -- | -- | 3.33 | 0.3254 | 12 | 1.33 | 0.3073 |
| 0.0000-0.2000 | Lowest | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **Total** | | 600 | 100.00 | 0.9439 | 300 | 100.00 | 0.8604 | 900 | 100.00 | 0.9072 |

Source: Calculation.

5. EXCESS INPUTS IN PRODUCTION

It was found that the 416 general rice growers should reduce excess inputs. The number represents 69.33 percent of all general rice growers. 228 farmers or 38.00 percent who should reduce two production factors. Also, 136 rice growers, accounting for 22.67 percent, should reduce one factor, while there 52 farmers, or 8.67 percent, should reduce three excess factors. Moreover, most organic farmers, 94 people or 31.33 percent, should reduce only one factor. Simultaneously, 54 organic rice growers or 18.00 percent, and three factors should be reduced among six farmers, representing 2.00 percent of the total number.

When comparing the production efficiency of both groups of farmers at the same time, it was revealed that the farmers would reduce only up to three production inputs. 333 farmers or 37.00 percent reduced one factor, while 174 farmers or 19.33 percent cut two factors. And, 30 rice growers, accounting for 3.33 percent, reduced three factors. As a result, there were 363 farmers or 40.33 percent of the total number of farmers in both groups who had not reduce excess inputs.

Table 3. Input slack.

| Input | General Rice | Healthy Rice | Total |
|-------|--------------|--------------|-------|
|       | Amount | Percent | Amount | Percent | Amount | Percent |
| Reduced 1 input | 136 | 22.67 | 94 | 31.33 | 333 | 37.00 |
| Reduced 2 input | 228 | 38.00 | 54 | 18.00 | 174 | 19.33 |
| Reduced 3 input | 52 | 8.67 | 6 | 2.00 | 30 | 3.33 |
| Number of farmer to reduce | 416 | 69.33 | 154 | 51.33 | 537 | 59.67 |
| Number of farmer to don’t reduce | 184 | 30.67 | 146 | 48.67 | 363 | 40.33 |

6. REDUCING EXCESS INPUTS IN PRODUCTION

Based on the evaluation of the rice production efficiency by comparing the use of production inputs among sample groups of farmers, the farmers were suggested that they reduce their production factors to get the same yield. The farmers of each level of efficiency, therefore, should reduce the size of production factors as follows.
6.1. Seed Quantity

4.33 percent of the total number of sample farmers who should reduce the seed quantity. The 32 effective general rice growers with the highest efficiency, representing 5.33 percent, should reduce the seed by an average of 20.80 kilograms, while the farmers who produced healthy rice with the highest production efficiency, 12 cases representing 4.00 percent, should reduce the excess factor by an average of up to 84.14 kilograms. Overall, rice farmers with high and the highest level of efficiency should cut the seeds used in the production by an average of 22.45 and 73.83 kg, respectively.

6.2. Soil Fertilizer Cost

132 general rice farmers, representing 22.00 percent, should reduce the fertilizer cost by an average cost of 2,521.25 baht. Also, four farmers with high productivity, 0.67 percent, should reduce the soil fertilizer cost by an average of 2,849.69 baht, while the average cost of fertilizer should be reduced by 1,133.78 baht among 40 farmers or 13.33 percent of those who produced organic rice. In addition, rice growers with moderate efficiency should reduce the average fertilizer cost by 2,438.81 baht. Overall, farmers with the highest efficiency should reduce the cost by the maximum average of 2,227.43 baht. And, farmers with high and medium efficiency were suggested that they reduce the average cost of soil fertilizer by 106.30 baht and 90.36 baht, respectively.

6.3. Weed Removal Cost

160 rice farmers, accounting for 26.67 percent, should reduce the cost of weeding. Most efficient farmers, 156 cases, representing 26.00 percent, should reduce the cost of weeding by an average of 866.96 baht. The farmers with high efficiency should reduce the cost of weeding by an average of 450.00 baht. Significantly, the organic rice growers had no weeding cost since such cost was for chemicals. Furthermore, when comparing between the two groups of farmers, there were 138 farmers, representing 15.33 percent, who should reduce such factor.

6.4. Labor Cost for Production

Labor cost was a production factor that was necessary to be reduced due to its relatively high number. The general farmers with high level of efficiency should reduce such cost by 8,474.14 baht. 256 farmers with the highest efficiency, 42.67 percent, should reduce the average labor cost by 2,228.63 baht, while the organic rice farmers with the most efficiency should reduce the labor cost by an average of 2,829.36 baht. Moreover, the average labor cost should be reduced by 6,243.23 baht among those with high efficiency, followed by the average labor cost of up to 35,311 to be reduced when considering that among the farmers with medium efficiency. Besides, when comparing between the two groups of farmers, it was discovered that those farmers should reduce the labor cost of production by a maximum average of 11,952.86 baht, which was said to be among the group of farmers with medium production efficiency.

6.5. Labor Cost for Harvesting

Despite its small number in value, labor cost for harvesting was also to be cut. Based on the analysis, only the general rice farmers with the highest level of efficiency who should reduce their labor cost for harvesting. The average value to be cut totaled 966.23 baht, among 160 or 26.67 percent. Meanwhile, the organic rice growers with the highest level of efficiency should reduce such cost by an average of 1,513.60 baht. Also, the farmers with the high level of efficiency should reduce the average cost of 1369.58 baht. Last but not least, after comparing all sample groups of farmers, it was unveiled that only farmers with the highest level of efficiency should reduce such labor cost by an average of 1124.11 baht.
7. ECONOMY OF SCALE

The goal of production of rice growers is to achieve maximum productivity, therefore, farmers need to use efficient production factors with the lowest cost to gain maximum profit. In accordance with the analysis comparing the production efficiency between the two groups of farmers, it was found that the majority of farmers, accounting for 426 people or 47.33 percent, had increasing returns to scale (IRS). Those were farmers with the least and the highest level of efficiency. The increasing returns to scale (IRS) and the constant returns to scale (CRS) amounted to were seen among 351 and 123 rice growers, accounting for 39.00 percent and 13.67 percent of the total number, respectively. When considering each group separately, it was seen that was most general rice growers and healthy rice growers produced had constant returns to scale (CRS). The number of each group were 596 and 186, respectively, representing 99.33 percent and 62.00 percent Table 4. Additionally, there is none of the general rice farmers facing decreasing returns to scale (DRS). Furthermore, 123 organic rice farmers, representing 27.33 percent, had increasing returns to scale (IRS). However, 32 organic rice farmers, accounting for 10.67 percent, had decreasing returns to scale (DRS).

| Level of Efficiency | General Rice | Healthy Rice | Total |
|---------------------|--------------|--------------|-------|
|                     | CRS | IRS | DRS | CRS | IRS | DRS | CRS | IRS | DRS |
| 0.8001-1.0000       | 548 | 42  | 30  | 152 | 42  | 30  | 123 | 303 | 333 |
| 0.6001-0.8000       | 44  | -   | -   | 18  | 24  | 2   | -   | 72  | 15  |
| 0.4001-0.6000       | 4   | -   | -   | 10  | 12  | -   | -   | 39  | 3   |
| 0.2001-0.4000       | -   | -   | -   | 6   | 4   | -   | -   | 12  | -   |
| 0.0000-0.2000       | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| Total               | 596 | 4   | 0   | 186 | 82  | 32  | 123 | 426 | 351 |
| Percent             | 99.33| 0.67| 0.00| 93.00| 41.00| 16.00| 13.67| 47.33| 39.00|

8. CONCLUSION

With regard to the analysis of rice production efficiency of the two groups of farmers, it was found that most farmers had the highest production efficiency. Specifically, the general rice farmers had higher production efficiency than the healthy rice farmers. Although the level of performance indicated such result, the amount of excess inputs used by the general rice farmers appeared to be higher. That is because most organic rice growers should reduce only one production factor, whereas most general rice farmers should adjust the production factors down by two factors. Besides, the proportion of those who should reduce their excess inputs was higher than that of the healthy rice farmers. To discuss this in more detail, the production factor that should be reduced the most was labor costs, in production and for harvesting, due to its unnecessarily high numbers which cost excess cost. The average labor cost to be reduced was up to an average of 8,474.14 baht, which was the cost among the general rice growers. Last but not least, the study results showed that when comparing the efficiency of the farmers in the same group, they had constant returns to scale (CRS). On the contrary, when comparing the production efficiency between groups, they had increasing returns to scale (IRS).

8.1. Suggestions

1. Government agencies should train or educate healthy rice farmers in terms of adjusting their production factors in order to lower costs and to generate more returns.

2. Agriculture-related agencies should focus on large-scale production in order to gather groups of farmers to create more bargaining power in the rice market.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: All authors contributed equally to the conception and design of the study.
REFERENCES

Ajibefun, A.I., G.E. Battese and A.G. Daramola, 1996. Investigation of factors influencing the technical efficiencies of smallholder croppers in Nigeria. Center for Efficiency and Productivity Analysis (CEPA) Working Paper No. 10/96. Department of Econometrics, University of New England, Armidale, Australia.

Araratanakun, H., 2003. Technical efficiency of the production of cut Dendrobium Orchids. Master of Science. Chiang Mai University.

Bates, M.B. and A.L. Flordeliza, 2010. Factors affecting yield performance of banana farms in Oriental Mindoro, Philippines. Journal of International Society for Southeast Asian Agriculture Science, 16(1): 110-120.

Battese, G.E., S.J. Malik and M.A. Gill, 1996. An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. Journal of Agricultural Economics, 47(1-4): 37-49.Available at: https://doi.org/10.1111/j.1477-9552.1996.tb00670.x.

Ben, B.B., 2000. Measurement and explanation of technical efficiency in Missouri hog production. Selected Paper, American Agricultural Economics Association (AAEA), Annual Meeting. Tampa, Florida, 30 July – 2 August.

Berger, A.N. and D.B. Humphrey, 1997. Efficiency of financial institutions: International survey and directions for future research. European Journal of Operational Research, 98(2): 175-212.Available at: https://doi.org/10.1016/s0377-2217(96)00342-6.

Charnes, A., W.W. Cooper, A. Lewin and S. L.M., 1995. Data envelopment analysis: Theory, methodology and applications. Dordrecht: Kluwer Academic Publishers.

Cheamuangphan, A., A. Wiboonpongse, Y. Chaovanapoonphol and S. Sriboonchitta, 2013. Factors enhancing production efficiency of farmer households who are members of saving groups in Upper Northern Thailand. The Empirical Econometrics and Quantitative Economics Letters, 2(2): 71-82.

Coelli, T., 1998. A multi-stage methodology for the solution of orientated DEA models. Operations Research Letters, 23(3-5): 143-149.Available at: https://doi.org/10.1016/s0167-6377(98)00036-4.

Coelli, T.J. and G.E. Battese, 1996. Identification of factors which influence the technical inefficiency of indian farmers. Australian Journal of Agricultural Economics, 40(2): 103-128.Available at: https://doi.org/10.1111/j.1467-8489.1996.tb00558.x.

Department of Foreign Trade, 2016. Report of rice export. Available from http://www.dft.go.th/th-th/Intro.

Helfand, S.M., 2003. Farm size and determinants of productive efficiency in the Brazilian Center-West. Paper Presented at the 25th International Conference of the International Association of Agricultural Economist (IAAE). Durban, South Africa, 16–22 August Leonard Kyei.

Jabbar, M.A. and S. Akter, 2008. Market and other factors affecting farm specific production efficiency in pig production in Vietnam. Journal of International Food & Agribusiness Marketing, 20(3): 29-53.Available at: https://doi.org/10.1080/08974430802157606.

Joel, M., 2005. Analysis of socio-economic factors affecting the production of Bananas in Rwanda: A Case Study of Kanama. Available from www.unipv.eu/on-line/en/.../documento5709.html.

Jutarat, P., 2002. Technical efficiency of Soybean production in the rainfed area of lower Northern region. Thailand. Master of Science. Chiang Mai University.

Kasikorn Research Center, 2013. Organic rice: The market potential is continuously growing. Available from https://positioningmag.com/34730.

Lyubov, A.K. and H.H. Jensen, 1998. Technical efficiency of grain production in Ukraine. Paper Presented at the 1998 American Agricultural Economics Association Annual Meeting, Salt Lake City, Utah, 2–5 August.

Nyemeck, J.B., K. Sylla and I. Diarra, 2001. Analysis of the determinants of the productive performance of coffee producers in a low-income area in Cote d’Ivoire. Final report. Nairobi: AERC.

Office of Agricultural Economics, 2014. Rice plantation area. Available from http://www.oae.go.th/assets/portals/1/files/production/fieldcrop/majorrice/1-57-58.pdf.
Omononona, B., A. Akanbi and O. Egbetokun, 2010. Farmers resource–use and technical efficiency in Cowpea Production In Nigeria. Economic Analysis and Policy, 40(1): 102-110.Available at: https://doi.org/10.1016/s0313-5926(10)50006-7.

Palee, J., 2012. Analysis of technical efficiency of glutinous rice production in Hang Dong District and San Pa Tong District, Chiangmai Province with Stochastic Production Frontier Models. Master of Science. Chiang Mai University.

Saima, A., Z. Hussain and M.H. Sial, 2010. Role of credit on production efficiency of farming sector in Pakistan (a data envelopment analysis). World Academy of Science, Engineering and Technology, 42(6): 1028-1033.

Seyoum, E., G.E. Battese and E. Fleming, 1998. Technical efficiency and productivity of maize producers in eastern Ethiopia: A study of farmers within and outside the Sasakawa-Global 2000 project. Agricultural Economics, 19(3): 341-348.Available at: https://doi.org/10.1016/s0169-5150(98)00037-1.

Stanton, K.R., 2002. Trends in relationship lending and factors affecting relationship lending efficiency. Journal of Banking & Finance, 26(1): 127-152.Available at: https://doi.org/10.1016/s0378-4266(00)00171-0.

Toshiyuki, S., 1999. DEA non-parametric ranking test and index measurement: Slack-adjusted DEA and an application to Japanese agriculture cooperatives. Omega, 27(3): 315-326.Available at: https://doi.org/10.1016/s0305-0483(98)00057-7.

Toshiyuki, S. and G. Mika, 2001. Slack-adjusted DEA for time series analysis: Performance measurement of Japanese electric power generation industry in 1984–1993. European Journal of Operational Research, 133(2): 232-259.Available at: https://doi.org/10.1016/s0377-2217(00)00295-2.
Cost and Benefit Analysis of Rice Production between Transplanting and Direct Seeded Method for Rice in Upper Northern Region

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Abstract: This research aims to examine rice production costs and returns as well as to focus on reducing inputs used by farmers implementing rice transplanting and direct seeding approaches. By studying the optimal use of agricultural inputs, excessive inputs are used to create a model of expected cost and return in terms of the budget procedure. The research result showed that costs and returns of the farmers reducing the production inputs were higher than those of the farmers not reducing their inputs. Simultaneously, the net return of the first group of farmers was statistically significantly lower. However, when the inputs had been reduced, the production cost of rice growers became lower. Also, the return was slightly higher due to the high production quality. Regarding the research findings, rice growers are suggested that they encourage household members give more importance to rice production in order to increase the potential for rice production with transplanting method which will result in higher production efficiency and higher return.

Keywords: Rice production, Transplanting, Direct seeding, Costs and returns

Received: 1 August 2018 / Accepted: 11 September 2018 / Published: 10 October 2018

INTRODUCTION

Rice is a grain and has been a major economic crop of Thailand for a long time. It is cultivated throughout the country. In the 2013/14 crop year, a total of 20.50 million tons of paddy were produced from the total cultivated area for rice of 69.9 million rais (Ayuningrat, Noermijati, & Hadiwidjojo, 2016; Nuansoi, Suntiniyompukdee, & Tahlah, 2017; Office of Agricultural Economics, 2015a), which was used for domestic consumption of 10.90 million tons; and the remaining was exported to the overseas market, valued at 174,851 million baht (Bilog, 2017; Office of Agricultural Economics, 2015b; Wartika, Surendro, Satramihardja, & Supriana, 2015; Willy, 2017). It can be said that rice has been consumed domestically and can also be exported to bring in a large amount of income each year. Thailand also has the highest share in the worlds rice market, although it lost market share to India in the 2012/13. It is noteworthy, nevertheless, that Thai farmers still suffer from losses. That is due to the cost of production which is likely to increase and the uncertainty of economics. Many farmers turn to mercenaries because of thecertainty of their income. That brings about the potential decline in the cultivation area for rice production.

In rice cultivation, there are essential inputs namely land, labor, management, as well as new inputs such as seeds, fertilizers, pesticides and various machinery. These factors, when properly allocated, can help increase productivity. When considering the farming practices, main practices are transplanting and direct seeding; and the direct seeding method also covers pre-germinated direct-seeding and direct seeding. The obvious difference between transplanting and the direct seeding is that the soil preparation procedure of transplanting is more refined than that of the direct-seeding. And, transplanting needs

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more labor. That is, direct-seeding can solve the shortage of labor (Janprasert, 1975). However, the disadvantage of direct-seeding or sowing is that it requires more seed by 8-10 kg/rai to be used and produces lower (Planning and Research Department of Agriculture, 2018). Significantly, the number of agricultural workers has been declining steadily since 1990, from 63.3% of total employed workers to only 42.1% in 2012 (Bank of Thailand Northeast office, 2013). Consequently, there is currently a shortage of agricultural workers.

The northern region is the second largest rice growing area after the Northeast. Even though the average rice yields per rai are lower than those of the central region, they are still higher than the national average. Significantly, the shortage of labor has become an issue. One of the causes of the shortage of labor is that farmers want their children to get high education and work comfortably in other fields. Farmers in the North, therefore, have turned to direct-seeding method. In addition, having a misconception about labor reduction, rice growers assume that it helps reduce production cost. Instead, they have to increase the use of chemicals to eliminate weeds and pests; whereas the rice is not strong enough.

It has become an interesting question: how are transplanting and direct-seeding different from each other in terms of production efficiency and which method is most efficient? It also raises the issue concerning the difference between cost of each production practices. All these questions are to bring about the best way to produce rice to rice growers in the upper northern region.

LITERATURE REVIEW AND RELATE THEORIES

Concepts and theories of cost and revenue

To study economic feasibility of rice farming, the focus will be on the net return on total variable cost of rice cultivation and will also be on the rice production cost per unit. To clarify, the cost-per-unit study will provide a break-even point. In addition, the analysis will be of return to most important inputs such as labor, by adopting a budgeting analysis with a calculation method provided below.

\[ TR = Y \times P \] (1)

\[ NR = TR - TVC \] (2)

- \( TR \) = Total revenue per rai (baht/rai)
- \( Y \) = Total rice yield (Kg / rai)
- \( P \) = Price of rice sold (baht/kg.)
- \( TVC \) = Total variable cost per rai (baht/rai)
- \( NR \) = Net return on variable cost (baht/rai)

Studies related to costs and benefits

Production costs consist of variable costs and fixed costs. In the analysis of costs and returns of production, costs are usually classified into two types: cash cost and non-cash cost. Variable costs include labor cost, cost of agricultural materials, expenses for agricultural equipment repair, and the opportunity cost for requesting funding. Fixed costs cover land use fees and land tax. The study found that the cost of organic rice production in Surin province was 1,917 baht per rai, which was higher than the average production cost of 1,828.57 baht per rai. However, the net return on organic rice production was 1,177.03 baht per rai. In the meanwhile, the net return of rice is only 425.51 baht per rai (Intan, 2016; Pali, 2012). Additionally, the costs of rice production using chemicals and of organic rice in Chiang Rai were compared. The organic rice production cost was up to 2,765.95 baht/rai. Simultaneously, the rice production cost using chemicals was approximately 2,639.03 baht/rai. Nonetheless, the net return of organic rice production accounted for 127.11 baht/rai (Anjani & Baihaqi, 2018; Arayarattanakul, 2003). Moreover, regarding the comparison of costs and returns of organic rice production and rice production using chemicals in Lamhukka district, Pathumthani, by analyzing the break-even points in the productions, it was disclosed that organic rice production had an average cost of 3,718.10 baht per rai. Organic rice farmers had an average income of 8,350.20 baht per rai. Meanwhile,
the average cost of rice production using chemicals equaled 4,534.08 baht per rai with the average income of 9,710.52 baht. Furthermore, the break-even point of organic rice production was 761.97 kg/rai, while that of the other type of production practice was 890.87 kg/rai. In other words, the break-even point of the organic rice production was lower than that of the rice production using chemicals (Coelli & George, 1996). In addition, when comparing the cost of organic rice and the cost non-toxic rice, it was revealed that organic rice had an inflated cost of 2,432.93 baht per rai, while the cost of organic rice production was 2,145.97 baht per rai. It is noteworthy that the organic farmers had a net income of 373.81 baht per rai; whereas those who farmed non-toxic rice lost 482.18 baht per rai. Besides, the level of yield and the price at the break-even point of non-toxic rice were higher than those of organic rice (Coelli & George, 1996).

In addition, according to the results of the cost and return analysis of rice production using chemicals and biological agents among farmers in Uttaradit province, it was evident the cost of chemical-adopting rice production amounted to 7,450 baht per rai. The cost of rice production with biological agents were 4,600 baht per rai. The non-biological farmers, as a result, wasted up to 1,990 baht per rai, as non-monetary cost which was household labor. However, when considering only cost and revenue in monetary terms, it was said that farmers who used chemicals still had lower net profits than farmers using biological agents (Ruangsang, Tewtrakul, & Reanmongkol, 2010). Another important study was on the concept of cost, return and break-even point of rice farming in Chiang Rai. Rice growers were divided into 6 groups with the consideration of their assets, which include tractors, and land tenure. The study found that farmers without plowed tractors, but with their own fields, had the lowest production costs. The highest income was for the group of farmers who had a tractor but rented a farm. Moreover, it was discovered that production problems were mainly caused by high fertilizer prices, expensive fuel prices, and decline of paddy prices (Janprasert, 1975). Last but not least, the comparison of costs and returns of rice production of cooperative and non-cooperative farmers, it was found that the farmers who were members of a cooperative had a greater net return than that of non-member farmers by 27 baht per rai (Supapan, 2012).

**Objectives**

1. To study the efficiency of rice production by transplanting and direct-seeding method of rice growers in the upper North.
2. To examine the costs and benefits of rice production, as well as the approaches to reduce the use of inputs in rice farming with both transplanting and direct-seeding method.

**Research scope**

The survey was conducted with sampling among rice farmers, who were divided into two groups according to their production practices: transplanting and direct-seeding, in the most rice-growing area in the upper North covering Chiang Mai, Chiang Rai and Phayao.

**RESEARCH METHOD**

Step 1: Find out the Technical Efficiency (TEF) of farm households, by using non-parametric technique based on DEA (Coelli & George, 1996).

Step 2: Divide the TEF of rice production by farmers into 5 levels. And, compare, to see differences and similarities, the efficiency of rice transplanting and direct-seeding.

Step 3: Analyze costs and returns from the usage of inputs in rice farming. Study the costs and the returns of rice production by considering their production practices: transplanting and direct-seeding, and the efficiency levels of their production. And, compare, to see the difference, the costs and the returns using t-statistic.

Step 4: Analyze the optimal use of inputs to reduce costs and increase yields for farmers adopting transplanting and for those employing direct-seeding method, by reducing the inputs derived from the...
estimation in the model to calculate the potential costs and returns with both cultivation methods and to see whether they are significantly different when using the \( t \)-statistic.

To determine the cost of production per unit, the prices of rice sold by farmers were compared in order to provide a break-even point. In addition, the analysis of returns on key inputs, such as labor, was made using the budgeting procedure (budgeting analysis) with the calculation method as follows.

\[ TR = Y \cdot P \]  
\[ NR = TR - TVC \]

Where:
- \( TR \) = Total revenue per rai (baht/rai)
- \( Y \) = Total rice yield (Kg / rai)
- \( P \) = Price of rice sold (baht/kg.)
- \( TVC \) = Total variable cost per rai (baht/rai)
- \( NR \) = Net return on variable cost (baht/rai)

**RESEARCH FINDINGS**

**Actual costs and returns**

The actual cost and return analysis (Table 1) was based on the data obtained from the farmers in order to analyze the worthiness of rice production.

**Production cost of rice farming with transplanting**

The average cost of production of farming with the medium level of efficiency was 4,973.48 baht/rai, while the lowest average cost, only 3,103.35 baht/rai, was for the group of farmers with the highest level of efficiency. The average cost of production of farmers in the groups, with high efficiency level and with low efficiency level, and was 3,762.34 baht/rai and 4,227.43 baht/rai, respectively. To be more specific, the highest cost was the cost of cultivation and transplanting which had been included in the cost of production. This is because the farmers chose the transplanting method that led to inflated cost. However, the cost of cultivating and transplanting, of the farmers with low and medium efficiency was higher than that of the farmers with high and highest efficiency levels. Additionally, the cost of inputs was mostly the cost of fertilizer. It was found that the farmers with low level of production efficiency spent up to 1,033.00 baht per rai on fertilizer. That is, the farmers were more accustomed to using fertilizer and tended to rely more on fertilizer every year. Besides, as using fertilizer results in soil mineral depletion, higher demand on fertilization rises every year.

**The revenue of rice farmers**

Based on the analysis of the revenue of the farmers, the price of rice was not significantly different. That is, firstly, the farmers with the highest production efficiency were able to sell rice at the price of 9.84 baht per kilogram. Secondly, the farmers with high efficiency were able to sell their rice at the price of 9.33 baht per kilogram. Meanwhile, those with the medium efficiency sold their rice at only 8.19 baht per kilogram. And, the farmers with less efficiency farmers sold their product at 9.00 baht per kilogram. It is noteworthy that the average yield was likely to increase as productivity decreased. To clarify, the average yield of the most efficient farmers was 761.29 kilograms per rai; whereas the average yield of the farmers with high efficiency was 827.79 kilograms per rai. Meanwhile, the farmers with low production efficiency had an average yield of 961.67 kilograms per rai. As a result, the least efficient farmers had the highest income, which was 8,655.03 baht per rai; and the lowest income was for the farmers with medium efficiency totaling 7,136.36 baht per rai. Plus, the high and highest efficient farmers income accounted for 7,723.28 baht per rai and 7,491.09 baht per rai, respectively.

**Net return of transplanted rice farmers**

With respect to the analysis of net return of transplanted rice farmers, it was found that the farmers with most and less production efficiency had the similar numbers of net return, which were 4,387.74
and 4,427.60 baht per rai in order. Simultaneously, the net return of the farmers with high efficiency totaled 3,960.94 baht per rai. And, the moderately efficient farmers earned only 2,162.88 baht per rai.

**Production cost of rice farming with direct-seeding method**

Based on the cost estimates of rice production, it was found that when the production efficiency decreased, the cost of rice production was likely to increase. To be clear on this point, the most efficient farmers bore the production cost of only 2,604.73 baht per rai, while the more efficient group of farmers had the higher cost of 2,890.76 baht per rai. The farmers with the production efficiency at moderate and low levels, their costs of production were 4,386.87 and 5,132.17 baht per rai, in order. Significantly, most of the cost during the production procedure was for harvesting and soil preparation as the key factors.

**Return on rice farming with direct-seeding method**

Regarding the return analysis of direct-seeding farming, it was revealed that prices of rice produced at various levels of production were different. That is, the farmers with the highest production efficiency were able to sell their rice at 10.59 baht per kilogram, when those with the efficiency at high level efficiency sold their product at a price of 10.67 baht per kilogram. Meanwhile, the farmers with medium efficiency could sell the product at 9.89 baht per kilogram; and less efficient farmers sold the product at a price of 8.33 baht per kilogram. Plus, the average yields fluctuated at each efficiency level.

To clarify, the average yield of the most efficient farmers equaled 748.52 kilograms per rai. At the high level of efficiency, the average yield of the farmers was 630.32 kilograms per rai. Meanwhile, the farmers with low productivity had the average yield of 990.91 kilograms per rai, when the least efficient farmers had the highest income, which was 8,254.28 baht per rai. Moreover, the farmers with high efficiency earned the least the lowest income, accounting for 6,725.51 baht per rai. And, the farmers with moderate efficiency and with high efficiency earned 7,531.93 baht per rai and 7,926.83 baht per rai, respectively.

**Net return on rice farming with direct-seeding method**

According to the analysis of net return of rice farmers implementing direct-seeding, it was unveiled that rice-growers with medium and low production efficiency had similar numbers of net return, of 3,145.06 and 3,122.11 baht per rai, respectively, which appeared to be quite low when compared to that, totaling 5,322.10 baht per rai. At the same time, those with high productivity level had the net return of 3834.75 baht per rai. It seemed to be obvious that the net return on rice farming with the direct-seeding method was likely to increase when the level of productivity of direct-seeded became higher.

**Reasonable costs and returns**

In the cost and return analysis of the two group of rice growers (Table 2), the level of the farmers income was fixed. Instead, the cost of input slack, derived from the efficiency analysis, were reduced. The results of the cost and net return are detailed as follows.

**Production cost of transplanted-rice farmers**

The average cost of production of the most efficient farmers was 3,097.16 baht per rai, which was lowered by 6.19 baht per rai. In the meantime, the farmers with high efficiency spent 3,693.44 baht per rai, which could be reduced by 68.90 baht per rai. Moreover, the average production cost of those with the medium and the low level of efficiency equaled 4,464.25 baht per rai and 3,777.77 baht per rai, respectively, and were reduced by 509.23 and 449.66 baht per rai, respectively. In addition, cost of inputs was mainly cost of fertilizers. The farmers with low efficiency did not reduce fertilizer use since fertilization appeared to be the only factor that contributed to their productivity. Yet, less efficient farmers could reduce the seed cost by up to 103.04 baht per rai.

**Net return of transplanted rice farmers**

Based on the net return analysis of rice-transplanting farmers, it was uncovered that all groups of farmers were able to increase net return. To be detailed, the farmers with the lowest level of efficiency
had the highest net return, which was 4,877.26 baht per rai. The second highest income, equaling 4393.94 baht per rice planters, was for those with productivity at the highest level. And, the farmers with high efficiency had a net return of 4,029.84 baht per rai, while that of those with medium efficiency was only 2,672.11 baht per rai.

*Production cost of direct-seeded rice growers*

Despite the reduction in the cost of rice production, it was still found that the cost of rice production was likely to increase, when the production efficiency decreased. The average cost of production of the most efficient farmers was 2,583.76 baht per rai, which could be reduced by 20.97 baht per rai; whereas the cost of the rice planters with high efficiency amounted to 2,754.61 baht per rai, which was reduced by 136.15 baht per rai. Simultaneously, the average cost of farmers with medium efficiency and with low efficiency totaled 3,708.44 baht per rai and 4,218.48 baht per rai, in order, which meant the production cost decline by 678.43 and 913.69 baht per rai, respectively. Furthermore, it was obvious that the cost of inputs covered mostly fertilizer, as the same as in the rice production with the transplanting method. However, the less efficient farmers could reduce their fertilizer cost and seed cost by 131.38 and 294.60 baht per rai, respectively.

*Net return of direct-seeded rice farmers*

By reducing the cost of rice production, the farmer’s net return increased. The farmers with the highest efficiency had a net return of 5,343.07 baht per rai; whereas the high-efficiency farmers had a net return of 3,970.90 baht per rai. Additionally, those with medium efficiency earned 3,823.49 baht per rai. And, the rice growers with low productivity showed a net return of 4,035.80 baht per rai.

*Additional returns*

At the diverse levels of rice production efficiency, it was found that less efficient rice farmers were able to sell their rice at the lower price than that of the farmers at the other levels, except for the direct-seeded rice growers who could sell their product at higher prices than those sold by the medium-efficiency group. If these two groups of farmers could increase their productivity and reduce their production costs, they would be able to increase their income and profit. Again, the most cost shouldered by the farmers was high due to the use of fertilizers, chemicals, soil preparation cost, and wages paid for labor helping with planting and harvesting. These were the easiest controlled inputs. In fact, controlling use of fertilizers and chemicals was easier than increasing the yield and could increase profits. Therefore, the excessive inputs obtained from the technical efficiency test were considered together with the cost and return analysis, as the farmer’s income remained the same. The results showed that the net profit of the transplanted rice farmers increased by an average of 84.51 baht per rai. Meanwhile, the net profit of the direct-seeded rice growers was an average of 289.68 baht per rai. It is noteworthy that, reducing the total use of excessive inputs helped increased the net return of the farmers by 383.77 baht per rai. Thus, it can be said that the reduction of lavish use of inputs will genuinely enhance the profits.

When the costs and the returns were analyzed together with the guidelines for reducing production inputs, it was found that direct-seeded rice growers could be more profitable than the transplanted rice farmers, particularly those who minimized the use of up to three types of inputs used for their production which could bring about an increase of their net return by 1151.55 baht per rai. Meanwhile, the rice farmers who lessened two types of inputs were able to lift their net returns by 696.02 baht per rai. And, the rice-transplanting farmers who cut the use of two inputs could raise their net return by 361.88 baht per rai.
Table 1: Actual average costs and returns of farmers (Baht per rai)

|                      | Transplanted Rice |                      | Direct-Seeded Rice |                      |
|----------------------|------------------|----------------------|--------------------|----------------------|
|                      | Highest          | High                 | Medium             | Low                 | Lowest              | Highest          | High                 | Medium             | Low                 | Lowest              |
| Revenue              | 7491.09          | 7723.28              | 7136.36            | 8655.03             |                    | 7926.83          | 6725.51              | 7531.93            | 8254.28             |                    |
| Prices               | 9.84             | 9.33                 | 8.19               | 9.00                |                    | 10.59            | 10.67                | 9.89               | 8.33                |                    |
| Yields               | 761.29           | 827.79               | 871.35             | 961.67              |                    | 748.52           | 630.32               | 761.57             | 990.91              |                    |
| Total costs          | 3103.35          | 3762.34              | 4973.48            | 4227.43             |                    | 2604.73          | 2890.76               | 4386.87            | 5132.17             |                    |
| Costs of inputs      | 1084.82          | 1287.30              | 1197.72            | 1711.67             |                    | 902.86           | 1071.98               | 1238.17            | 1783.32             |                    |
| Seed cost            | 277.36           | 176.63               | 189.71             | 140.00              |                    | 174.52           | 209.03                | 254.19             | 509.95              |                    |
| Fertilizer           | 602.58           | 833.11               | 700.55             | 1033.00             |                    | 577.52           | 648.64                | 820.24             | 989.70              |                    |
| Chemicals            | 162.06           | 230.73               | 202.70             | 534.67              |                    | 100.89           | 115.77                | 99.16              | 219.56              |                    |
| Fuel and lubricants  | 40.44            | 43.35                | 92.75              | 0.00                |                    | 34.49            | 95.68                 | 60.35              | 53.44               |                    |
| Ditch maintenance    | 2.38             | 3.48                 | 12.01              | 4.00                |                    | 15.44            | 2.86                  | 4.23               | 10.67               |                    |
| Costs in production  | 2018.53          | 2475.04              | 3775.76            | 2515.76             |                    | 1701.87          | 1818.78               | 3148.70            | 3348.85             |                    |
| procedure            |                  |                      |                    |                    |                    |                  |                      |                    |                    |                    |
| Soil preparation     | 367.82           | 454.47               | 736.73             | 66.67               |                    | 474.94           | 359.21                | 746.18             | 1455.45             |                    |
| Planting             | 623.74           | 668.45               | 1063.56            | 1044.95             |                    | 168.68           | 189.00                | 351.70             | 306.67              |                    |
| and sowing/growing   |                  |                      |                    |                    |                    |                  |                      |                    |                    |                    |
| Added planting       | 67.68            | 99.71                | 139.31             | 310.00              |                    | 52.74            | 67.71                 | 252.29             | 146.06              |                    |
| Fertilization        | 60.77            | 77.68                | 251.31             | 80.00               |                    | 59.79            | 153.14                | 196.44             | 183.13              |                    |
| Spraying herbicides  | 116.20           | 116.90               | 243.85             | 40.00               |                    | 51.63            | 108.99                | 148.57             | 178.49              |                    |
| and insecticides     |                  |                      |                    |                    |                    |                  |                      |                    |                    |                    |
| Water use management | 38.21            | 67.87                | 92.26              | 310.00              |                    | 23.89            | 45.73                 | 239.55             | 149.90              |                    |
| Harvest              | 570.19           | 616.68               | 702.07             | 316.67              |                    | 645.95           | 697.90                | 732.90             | 634.44              |                    |
| After-harvest        | 173.92           | 373.28               | 546.67             | 347.47              |                    | 224.25           | 197.10                | 481.07             | 294.71              |                    |
| management           |                  |                      |                    |                    |                    |                  |                      |                    |                    |                    |
| Net Return per Rai   | 4387.74          | 3960.94              | 2162.88            | 4427.60             |                    | 5322.10          | 3834.75               | 3145.06            | 3122.11             |                    |
Table 2: Reasonable average costs and returns of farmers (Baht per rai)

|                          | Transplanted Rice |                          | Direct-Seeded Rice |                          |
|--------------------------|-------------------|--------------------------|--------------------|--------------------------|
|                          | Highest          | High                     | Medium             | Low                     | Lowest                    | Highest          | High                     | Medium             | Low                     | Lowest                    |
|                          |                   |                         |                    |                        |                          |                   |                         |                    |                        |                          |
| Revenue                  | 7491.09          | 7723.28                  | 7136.36            | 8655.03                | -                        | 7926.83          | 6725.51                  | 7531.93            | 8254.28                | -                        |
| Prices                   | 9.84             | 9.33                     | 8.19               | 9.00                   | -                        | 10.59            | 10.67                    | 9.89               | 8.33                   | -                        |
| Yields                   | 761.29           | 827.79                   | 871.35             | 961.67                 | -                        | 748.52           | 630.32                   | 761.57             | 990.91                 | -                        |
| Total costs              | 3097.16          | 3693.44                  | 4464.25            | 3777.77                | -                        | 2583.76          | 2754.61                  | 3708.44            | 4218.48                | -                        |
| Costs of inputs         |                   |                         |                    |                        |                          |                   |                         |                    |                        |                          |
| Seed cost                | 276.75           | 168.90                   | 166.05             | 36.96                  | -                        | 173.41           | 197.57                   | 222.85             | 378.57                 | -                        |
| Fertilizer               | 602.52           | 818.06                   | 583.46             | 1033.00                | -                        | 571.60           | 643.21                   | 734.98             | 695.10                 | -                        |
| Chemicals                | 162.06           | 230.73                   | 292.70             | 534.67                 | -                        | 100.89           | 115.77                   | 99.16              | 219.56                 | -                        |
| Fuel and lubricants      | 40.44            | 43.35                    | 92.75              | 0.00                   | -                        | 34.49            | 95.68                    | 60.35              | 53.44                  | -                        |
| Ditch maintenance        | 2.38             | 3.48                     | 12.01              | 4.00                   | -                        | 15.44            | 2.86                     | 4.23               | 10.67                  | -                        |
| Costs in production procedure | 2013.01   | 2428.92                  | 3407.28            | 2169.14                | -                        | 1687.93          | 1699.52                  | 2586.87            | 2861.14                | -                        |
| Soil preparation         | 367.00           | 451.43                   | 699.44             | 62.50                  | -                        | 467.80           | 343.36                   | 621.53             | 1243.64                | -                        |
| Planting and sowing/growing | 622.14   | 628.36                   | 879.35             | 869.14                 | -                        | 168.47           | 188.77                   | 322.42             | 287.52                 | -                        |
| Added planting fertilization | 67.26    | 99.30                    | 126.14             | 269.11                 | -                        | 51.89            | 63.11                    | 180.89             | 126.10                 | -                        |
| Spraying herbicides and insecticides | 116.00 | 116.48                  | 220.28             | 37.50                  | -                        | 50.37            | 100.32                   | 138.32             | 147.72                 | -                        |
| Water use management    | 37.59            | 67.75                    | 79.26              | 269.11                 | -                        | 23.63            | 40.59                    | 141.42             | 119.55                 | -                        |
| Harvest                 | 569.36           | 616.00                   | 666.56             | 261.00                 | -                        | 643.28           | 645.86                   | 626.94             | 534.43                 | -                        |
| After-harvest management | 173.09           | 372.25                   | 500.44             | 325.77                 | -                        | 223.07           | 181.40                   | 385.60             | 237.94                 | -                        |
| Net Return Per Rai      | 4393.93          | 4029.84                  | 2672.11            | 4877.26                | -                        | 5343.07          | 3970.90                  | 3823.49            | 4035.80                | -                        |
DISCUSSION AND CONCLUSION

The income of transplanted rice farmers was higher than that of direct-seeded rice farmers. At the same time, the cost of transplanted rice production was higher than that of transplanted rice. However, the net return of transplanted rice farmers was higher than that of direct-seeded rice farmers. Besides, regarding the t-statistic test, it was demonstrated that the net returns of the two group of rice growers were significantly correlated with the efficiency level at the statistical significance level of 0.05, with a direct variation. To clarify, if the farmers have high efficiency, they will have a high return. On the contrary, if the farmers have lower productivity levels, a net return of the farmers will be lower. Moreover, it was revealed that most of the production cost is mainly the expenses during the production procedure. By reducing unnecessary costs, therefore, it was evident that the net returns were lifted. Furthermore, when efficiency decreased, the net returns increased. In addition, the low efficiency farmers were required to cut more production inputs than those of the high efficiency rice planters. And, as the rice growers had used a lot of excessive inputs, with the reduction of production inputs, the average yield of the direct-seeded rice farmers was higher than that of the transplanted rice farmers. Plus, based on the t-statistic test to examine the correlation between the net returns after the reduction of excessive inputs and the production efficiency, it was unveiled the net returns were correlated, in the same direction, with the production efficiency at the statistical significance level of 0.10.

SUGGESTIONS

1. Farmers are suggested that they adjust their use of inputs to suit their production conditions and to reduce unnecessary costs.
2. Officials in related agencies, such as agricultural cooperatives and Provincial Agricultural Offices, are suggested that they give advice to farmers on a proper use of rice production inputs for production worthiness.

ACKNOWLEDGEMENT

This study, the Cost and Benefit Analysis of Rice Production between Transplanting and Direct Seeding Method for rice in Upper Northern Region, was supported by the Higher Education Research Promotion and National Research University Project of Thailand, Office of the Higher Education Commission, in fiscal year 2016.

REFERENCES

Anjani, B. R., & Baihaqi, I. (2018). Comparative analysis of financial Production Sharing Contract (PSC) cost recovery with PSC gross split: Case study in one of the contractor SKK Migas. Journal of Administrative and Business Studies, 4(2), 65-80. doi:https://doi.org/10.20474/jabs-4.2.2

Arayarattanakul, H. (2003). Technical performance of cut flower production of dendrobium orchids (Unpublished master thesis). Chiang Mai University, Chiang Mai, Thailand.

Ayuningrat, M. P., Noermijati, & Hadiwidjojo, D. (2016). Green product innovations effect on firm performance of managerial environmental concern and green communication. Journal of Administrative and Business Studies, 2(2), 56-63. doi:https://doi.org/10.20474/jabs-2.2.1

Bank of Thailand Northeast office. (2013). Labor and the change of Thai agriculture. Retrieved from https://bit.ly/200QJJO (accessed on 15 July, 2017)

Bilog, D. Z. (2017). Investigating consumer preferences in selecting buffet restaurants in Davao region, Philippines. Journal of Administrative and Business Studies, 3(5), 221-233. doi:https://doi.org/10.20474/jabs-3.5.4

Coelli, T. J., & George, E. B. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. Australian Journal of Agricultural Economics, 40(2), 103-128. doi:https://doi.org/10.1111/j.1467-8489.1996.tb00558.x

Intan, W. S. (2016). The analysis factors of experiential marketing, product quality, and customer satisfaction of motor bike as a main transportation mode in Bandung-Indonesia. International Journal of Business and Administrative Studies, 2(1), 6-8. doi:https://doi.org/10.20469/ijbas.2
Janprasert, J. (1975). *Economic analysis of transplanting and direct-seeding in suphan buri, years 1972-1973* (Unpublished master’s Thesis). Kasetsart University, Bangkok, Thailand.

Nuansoi, W., Suntiniyompukdee, A., & Tahlah, A. (2017). Rice production in rattaphum district, Songkhla province, Thailand. *International Journal of Business and Economic Affairs, 2*(1), 18-30. doi:https://doi.org/10.24088/ijbea-2017-21004

Office of Agricultural Economics. (2015a). *Agricultural land use*. Retrieved from https://bit.ly/2TPL0QX (accessed on 14 January, 2016)

Office of Agricultural Economics. (2015b). *Export value of rice*. Retrieved from https://bit.ly/2JQsMCd (accessed on 14 July, 2016)

Pali, J. (2012). *Technical efficiency analysis of glutinous rice production in Hang Dong and San Pa Tong districts, Chiang Mai province, using stochastic nonparametric envelopment of data* (Unpublished master thesis). Chiang Mai University, Chiang Mai, Thailand.

Planning and Research Department of Agriculture. (2018). *Recommendations for new pre-germinated direct seeding approach*. Retrieved from https://bit.ly/2FaOGyu (accessed on 16 July, 2018)

Ruangsang, P., Tewtrakul, S., & Reanmongkol, W. (2010). Evaluation of the analgesic and anti-inflammatory activities of curcuma mangga Val and Zijp rhizomes. *Journal of Natural Medicines, 64*(1), 36-40. doi:https://doi.org/10.1007/s11418-009-0365-1

Supapan, P. (2012). *Technical efficiency and worthiness analysis on organic longan production in the Northern Region of Thailand* (Unpublished master thesis). Maejo University, Nong Han, Chiang Mai.

Wartika, K., Surendro, H., Satramihardja, I., & Supriana. (2015). Business process improvement conceptual models to improve the efficiency of power consumption on computer use from the perspective of human resource performance. *International Journal of Business and Administrative Studies, 1*(3), 99-106. doi:https://doi.org/10.20469/ijbas.10004-3

Willy, S. (2017). Analysis of financial ratios to measure the company’s performance in the sectors of consumer goods at Pt. Nippon Indosari Corpindo, Tbk and Pt. Mayora Indah, Tbk. *International Journal of Business and Economic Affairs, 2*(1), 45-51. doi:https://doi.org/10.24088/ijbea-2017-21006
This paper aimed to analyze the efficiency of rice production methods between transplanting and direct seeding of farmers in the upper northern region, and to find the factors affecting the efficiency of rice production. The study adopted DEA as the benchmarking method in the analysis of the efficiency of rice production by means of Tobit model. The results showed that a number of farmer household invested by themselves to produce the rice production. While own investment influenced negative direction on the efficiency, education level had effect on positive.

Keywords: effectiveness, rice production, transplanting rice, direct seed rice
ประกอบด้วยนาด้าและนาหว่าน โดยนาหว่านยังแบ่งออกเป็นนาหว่านน้ำส้าและนาหว่านต้มซึ่งข้อแตกต่างระหว่างการท่าน้าด้าและนาหว่านที่เห็นได้ชัดเจนคือการท่าน้าด้าต้องมีกรรมวิธีในการเตรียมดินเพื่อปักด้ามีความประณีตกว่าการท่าน้าด้า และต้องใช้แรงงานมากในการปักด้าแต่นาหว่านสามารถตัดปัญหาการปักด้าออกไปได้ซึ่งเป็นการแก้ปัญหาขาดแคลนแรงงาน (จงเจตน, 2518)แต่ข้อเสียของนาหว่านคือต้องใช้เมล็ดพันธุ์มากกว่าน้ำต้าประมาณ 8-10 กก.ต่อไร่และให้ผลผลิตต่ำกว่าน้ำต้า (กองแผนงานและวิชาการ, 2524)อย่างไรก็ตามจำวนแรงงานจากเกษตรกรตลอดอย่างต่อเนื่องจากระหว่างปี พ.ศ. 2553 ซึ่งมีแรงงานร้อยละ 63.3 ของผู้มีงานทั้งปี พ.ศ. 2555 เหลือเพียงร้อยละ 42.1เท่านั้น (ธนาคารแห่งประเทศไทย, 2556)ทำให้ปัจจุบันเกิดความขาดแคลนแรงงานมากกว่า

ภาคเหนือก็เป็นอีกภาคหนึ่งที่มีพื้นที่ที่ปลูกข้าวเป็นอันดับสองรองจากภาคกลางรองลงมามีบริมาณผลผลิตข้าวมากกว่ารองจากภาคกลางแต่ยังสูงกว่าค่าเฉลี่ยของประเทศ และยังคงประสบปัญหาขาดแคลนแรงงานในภาคเกษตรเนื่องจากเกษตรกรเลือกว่าการเป็นคนงานในภาคนี้จะต้องการให้บรรดาบ hàiรับการเลือกเพื่อให้บรุตตาได้รับการทำงานในสนามเกษตรกรที่มีที่ดินที่จะวิเคราะห์ค่าประสิทธิภาพการผลิตของครัวเรือนเกษตรกรจะมีปัจจัยที่มีผลต่อระดับประสิทธิภาพการผลิตของเกษตรกรผู้ปลูกข้าวจึงได้กำหนดวัตถุประสงค์เพื่อวิเคราะห์ประสิทธิภาพการผลิตข้าวโดยการผลิตแบบนาด้าและนาหว่านของเกษตรกรผู้ปลูกข้าวในภาคเหนือตอนบนและวิเคราะห์ปัจจัยที่มีความสำคัญต่อประสิทธิภาพการผลิตข้าวของเกษตรกร ขอบเขตการวิจัยครั้นนี้ในการสำรวจจะสุ่มตัวอย่างเกษตรกรผู้ปลูกข้าวโดยจำแนกวิธีการปลูก 2 ประเภท คือ การปลูกข้าวแบบนาด้าและการปลูกข้าวแบบนาหว่าน ในพื้นที่จังหวัดเชียงใหม่ เชียงราย และพะเยา ซึ่งเป็นจังหวัดที่มีพื้นที่ปลูกข้าวมากที่สุดในภาคเหนือตอนบน

วิธีดำเนินการวิจัย

การศึกษาวิจัยเรื่องประสิทธิภาพการผลิตข้าวระหว่างนาด้าและนาหว่านของเกษตรกรในภาคเหนือตอนบนได้ทำการสุ่มตัวอย่างแบบเฉพาะเจาะจงจากเกษตรกรผู้ปลุกข้าวจำนวน 1,050 ครัวเรือนซึ่งมีวิธีดำเนินการวิจัยประมาณดังนี้

ขั้นตอนที่ 1 ทำค่าประสิทธิภาพการผลิตของครัวเรือนเกษตรกร (TE)

ประสิทธิภาพการผลิตของครัวเรือนเกษตรกรวิเคราะห์โดยใช้เทคนิคของ Non-parametric ซึ่งอยู่บนพื้นฐานของ DEA (Coelli and Battese, 1996) ซึ่งการวิเคราะห์ค่าประสิทธิภาพการผลิตของครัวเรือนจะเป็นแบบ Output-oriented เนื่องจากเกษตรกรต้องการปริมาณผลผลิตมากที่สุดและให้คุณภาพผลผลิตที่มีอยู่อย่างจำกัดโดยมีปัจจัยจำกัดดังนี้


g   \sum_{\mu} \mu, y_{\mu} \leq 0 \quad (1)

\sum_{\mu} \mu, y_{\mu} - \sum_{i=1}^{m} \nu_{i} x_{ij} \leq 0 \quad (2)

\sum_{\mu} \mu, y_{\mu} = 1 \quad (3)

\nu_{i} x_{ij} = 1 \quad (4)

\mu, \nu \geq 0 \quad (5)
โดยที่ $Z$ คือ คะแนนประสิทธิภาพรวมของครัวเรือนเกษตรกรทั้งหมด $y_r$ คือผลผลิตชนิดที่ $r$ ของครัวเรือนเกษตรกรที่ $j$ และ $\mu_r$ คือ ค่าเฉลี่ยของผลผลิตชนิดที่ $r$ เมื่อ $r = 1, 2, ..., s$ ส่วน $x_{ij}$ คือปัจจัยการผลิตชนิดที่ $i$ ของครัวเรือนเกษตรกรที่ $j$ และ $\mu_i$ คือค่าเฉลี่ยของปัจจัยการผลิตชนิดที่ $i$ เมื่อ $i = 1, 2, ..., m$.

ขั้นตอนที่ 2 จำแนกประสิทธิภาพการผลิตข้าวของเกษตรกร (TEF) โดยจำแนกประสิทธิภาพออกเป็น 5 ระดับ (Table 1) นอกจากนี้ทำการเปรียบเทียบประสิทธิภาพการผลิตระหว่างนาด้าและนาหว่านว่ามีประสิทธิภาพต่างกันอย่างไร

| Efficiency score level | Meaning       |
|-------------------------|---------------|
| 0.8001-1.0000           | Very high     |
| 0.6001-0.8000           | High          |
| 0.4001-0.6000           | Medium        |
| 0.2001-0.4000           | Low           |
| 0.0000-0.2000           | Very low      |

ผลการวิจัย

ข้อมูลที่ใช้ในการศึกษาในครั้งนี้มีตัวแปรด้านผลผลิต คือปริมาณผลผลิตข้าว (O) โดยปริมาณผลผลิตเฉลี่ยตัววินัยต่ำที่เท่ากับ 8,204.59 กก. สูงสุดกว่าปริมาณผลผลิตเฉลี่ยตัววินัยต่ำที่เท่ากับ 6,408.42 กก.

ในส่วนตัวแปรด้านปัจจัยการผลิต จะประกอบไปด้วยปริมาณเมล็ดพันธุ์ ($I_1$) ปริมาณปุ๋ย ($I_2$) จำนวนชั่วโมงการทำงาน ($I_3$) โดยเกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาด้าจะใช้เมล็ดพันธุ์ข้าวเฉลี่ยเท่ากับ 105.26 กก. ส่วนเกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาหว่านจะต้องใช้เมล็ดพันธุ์ข้าวเฉลี่ยเท่ากับ 162.23 กก. ส่วนปริมาณปุ๋ยที่ใช้ในการปลูกข้าวได้แก่ปุ๋ยอินทรีย์และปุ๋ยเคมีพบว่าเกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาด้าจะใช้ปริมาณปุ๋ยเคมีเท่ากับ 556.95 กก. ในขณะที่เกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาหว่านใช้ปริมาณปุ๋ยเคมีเท่ากับ 491.61 กก. และเนื่องจากการปลูกข้าวด้วยวิธีนาด้าต้องอาศัยแรงงานและเวลาในการเพาะปลูกจึงทำให้มีการใช้แรงงานเฉลี่ยของเกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาต่ำกว่า 173.68 ชั่วโมง ขณะที่เกษตรกรที่เลือกปลูกข้าวด้วยวิธีนาหว่านมีจำนวนชั่วโมงที่ทำงานเฉลี่ย 103.75 ชั่วโมง.
ผลจากการวิเคราะห์ประสิทธิภาพการผลิตข้าวโดยการผลิตแบบนาด้าและนาหว่านของเกษตรกรผู้ปลูกข้าวในภาคเหนือตอนบนพบว่าระดับประสิทธิภาพของการผลิตข้าวทั้ง 2 แบบสามารถอธิบายผลการวิเคราะห์ได้ดังนี้

ประสิทธิภาพการผลิตข้าวนาด้าของเกษตรกรมีค่าเฉลี่ยเท่ากับ 0.7794 โดยเกษตรกรผู้ปลูกข้าวส่วนใหญ่ร้อยละ 50.29 มีประสิทธิภาพการผลิตมากที่สุด รองลงมาจะอยู่ในระดับมากร้อยละ 28.57 และระดับปานกลางร้อยละ 18.86 ส่วนระดับน้อยมีเพียงร้อยละ 2.29 โดยไม่มีเกษตรกรที่มีประสิทธิภาพการผลิตต่ำที่สุด (Table 2)

ประสิทธิภาพการผลิตข้าวนาหว่านมีค่าเฉลี่ยเท่ากับ 0.7211 โดยเกษตรกรผู้ปลูกข้าวส่วนใหญ่ร้อยละ 45.14 มีประสิทธิภาพการผลิตมากที่สุด รองลงมาในระดับมากร้อยละ 32.00 และระดับปานกลางมีสัดส่วนร้อยละ 17.14 ส่วนระดับน้อยมีเพียงร้อยละ 5.71 และไม่มีเกษตรกรรายใดที่มีประสิทธิภาพการผลิตต่ำที่สุดเช่นกัน (Table 3)

ด้านประสิทธิภาพการผลิตข้าวในภาคเหนือตอนบน จากผลการวิเคราะห์ประสิทธิภาพการผลิตข้าวของเกษตรกรพบว่าเกษตรกรผู้ปลูกข้าวนาด้ามีประสิทธิภาพสูงกว่านานว่าโดยเกษตรกรผู้ปลูกข้าวนาหว่านในภาคเหนือตอนบนส่วนใหญ่มีประสิทธิภาพมากที่สุดร้อยละ 41.14 ด้วยค่าคะแนนประสิทธิภาพเท่ากับ 0.9457 รองลงมาคือมีประสิทธิภาพอยู่ในระดับมาก คิดเป็นร้อยละ 36.86 ด้วยค่าคะแนนประสิทธิภาพเท่ากับ 0.6908 ในขณะที่ไม่มีเกษตรกรรายใดที่มีประสิทธิภาพอยู่ในระดับน้อยที่สุดดังนั้น ภาพรวมของประสิทธิภาพในการผลิตข้าวของเกษตรกรในภาคเหนือตอนบนจึงมีประสิทธิภาพอยู่ในระดับมากค่าคะแนนเท่ากับ 0.7407 (Table 3)
Table 3  Efficiency scores

| Efficiency level | Transplanting rice | Direct seeding rice | Total |
|------------------|--------------------|---------------------|-------|
|                   | No.   | %     | TE Avg. | No.   | %     | TE Avg. | No.   | %     | TE Avg. |
| Very high         | 264   | 50.29 | 0.9533  | 168   | 32.00 | 0.9397  | 432   | 41.14 | 0.9457  |
| High              | 150   | 28.57 | 0.6882  | 237   | 45.14 | 0.6916  | 387   | 36.86 | 0.6908  |
| Medium            | 99    | 18.86 | 0.5191  | 90    | 17.14 | 0.5189  | 189   | 18.00 | 0.5190  |
| Low               | 12    | 2.29  | 0.3005  | 30    | 5.71  | 0.3212  | 42    | 4.00  | 0.3175  |
| Very low          | 0     | 0.00  | 0.0000  | 0     | 0.00  | 0.0000  | 0     | 0.00  | 0.0000  |
| **Total**         | 525   | 100.00 | 0.7794  | 525   | 100.00 | 0.7211  | 1,050 | 100.00 | 0.7407  |

ตัวแปรที่ใช้ในการวิเคราะห์ปัจจัยที่มีผลต่อประสิทธิภาพการผลิตข้าวโดยใช้แบบจำลอง Tobitประกอบด้วยตัวแปรที่มีค่าสูงสุด ต่ำสุด ค่าเฉลี่ย และค่าส่วนเบี่ยงเบนมาตรฐาน (Table 4) ดังนี้

ราคาข้าวที่เกษตรกรได้รับ ($X_1$) มีค่าสูงสุดเท่ากับ 35 บาท/กก. ค่าต่ำสุดเท่ากับ 0.00 บาท/กก. เนื่องจากเกษตรกรบางรายมีวัตถุประสงค์ในการผลิตข้าวไว้เพื่อบริโภคในครัวเรือน ขณะที่มีราคาเฉลี่ยเท่ากับ 10.04 บาท/กก. และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 3.99 บาท/กก.

จำนวนสมาชิกที่เป็นเกษตรกร ($X_2$) มีค่าสูงสุดเท่ากับ 5 คน/ครัวเรือน ค่าต่ำสุดเท่ากับ 1 คน/ครัวเรือน ขณะที่มีจำนวนสมาชิกเฉลี่ยเท่ากับ 2 คน/ครัวเรือน และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.74 คน/ครัวเรือน

จำนวนเงินลงทุนในภาคการเกษตร ($X_3$) มีค่าสูงสุดเท่ากับ 1,500,000 บาท/ปี ค่าต่ำสุดเท่ากับ 5,000 บาท/ปี ขณะที่มีค่าเฉลี่ยเท่ากับ 95,796.93 บาท/ปี และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 180,223.33 บาท/ปี

วิธีการผลิต ($X_4$) มีค่าสูงสุดเท่ากับ 1 หมายถึงเกษตรกรผลิตโดยวิธีการปลูก ค่าต่ำสุดเท่ากับ 0 หมายถึงเกษตรกรผลิตโดยวิธีการเลี้ยง ขณะที่มีค่าเฉลี่ยเท่ากับ 0.66 และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.47

การศึกษาชั้นประถมศึกษา ($X_6$) มีค่าสูงสุดเท่ากับ 1 หมายถึงเกษตรกรมีระดับการศึกษาชั้นประถมศึกษา ค่าต่ำสุดเท่ากับ 0 หมายถึงเกษตรกรมีระดับการศึกษาในระดับอื่น ขณะที่มีค่าเฉลี่ยเท่ากับ 0.68 และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.47

การศึกษาชั้นมัธยมศึกษา ($X_7$) มีค่าสูงสุดเท่ากับ 1 หมายถึงเกษตรกรมีระดับการศึกษาชั้นมัธยมศึกษา ค่าต่ำสุดเท่ากับ 0 หมายถึงเกษตรกรมีระดับการศึกษาในระดับอื่น ขณะที่มีค่าเฉลี่ยเท่ากับ 0.14 และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.35

การศึกษาระดับปริญญาตรีหรือสูงกว่า ($X_8$) มีค่าสูงสุดเท่ากับ 1 หมายถึงเกษตรกรมีระดับการศึกษาชั้นปริญญาตรีหรือสูงกว่า ค่าต่ำสุดเท่ากับ 0 หมายถึงเกษตรกรมีระดับการศึกษาในระดับอื่น ขณะที่มีค่าเฉลี่ยเท่ากับ 0.07 และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.25

ฤดูการผลิต ($X_9$) มีค่าสูงสุดเท่ากับ 1 หมายถึงเกษตรกรมีการผลิตข้าวทั้งฤดูนาปีและนาปรัง ค่าต่ำสุดเท่ากับ 0 หมายถึงเกษตรกรมีการผลิตข้าวฤดูนาปีเพียงฤดูเดียว ขณะที่มีค่าเฉลี่ยเท่ากับ 0.27 และส่วนเบี่ยงเบนมาตรฐานเท่ากับ 0.45
ผลจากการวิเคราะห์ปัจจัยที่มีความสำคัญต่อประสิทธิภาพการผลิตข้าวของเกษตรกร พบว่าปัจจัยที่มีผลต่อระดับประสิทธิภาพการปลูกข้าวของเกษตรกรในเขตภาคเหนือตอนบนอย่างมีนัยสำคัญทางสถิติ ที่ทำมาหาก์ ค่า Marginal effect สรุปได้ดังนี้ (Table 5)

หากจ้านวนสมาชิกในครัวเรือนที่เป็นเกษตรกร (X₁) เพิ่มขึ้น 1 คน มีโอกาสทำให้ประสิทธิภาพการผลิตของเกษตรกรลดลงร้อยละ 5.31 ทั้งนี้เนื่องจากการผลิตของเกษตรกรอยู่ในช่วงผลได้ต่อขนาดที่ลดลง

หากปริมาณเงินทุนทางการเกษตรต่างๆ (X₃) เพิ่มขึ้น 10,000 บาท มีโอกาสทำให้ประสิทธิภาพการผลิตข้าวลดลงร้อยละ 1.08 ทั้งนี้เนื่องจากเกษตรกรต้องการความสะดวกสบาย ดังนั้นแม้ว่าเกษตรกรจะมีเงินทุนเพิ่มมากขึ้น แต่กลับมีความยินดีที่จะจ่ายเงินเพื่อซื้อปัจจัยการผลิตจ้าพวกปุ๋ยและยาใช้ทดแทนการดูแลด้านข้างด้วยตนเอง ทำให้ต้นทุนการผลิตเพิ่มสูงขึ้นจึงส่งผลกระทบต่อประสิทธิภาพการผลิตด้วย

หากเกษตรกรมีระดับการศึกษาชั้นประถมศึกษา (X₆) มีโอกาสทำให้ประสิทธิภาพการผลิตข้าวเพิ่มขึ้นร้อยละ 6.37 ทั้งนี้เนื่องจากเกษตรกรที่มีระดับการศึกษาอยู่ในระดับดังกล่าว ซึ่งมีประสบการณ์ในการปลูกข้าวมากกว่าแต่บรรทุก

| Variable | Max | Min | Mean | Standard Deviation |
|----------|-----|-----|------|--------------------|
| PRICE    | 35  | 0.00| 10.04| 3.99              |
| NAGRO    | 5   | 1.00| 2.00 | 0.74              |
| INVEST   | 1,500,000 | 5,000.00 | 95,796.93 | 180,223.33 |
| METHOD   | 1   | 0.00| 0.66 | 0.47              |
| LOANING  | 1   | 0.00| 0.66 | 0.47              |
| EDUC1    | 1   | 0.00| 0.68 | 0.47              |
| EDUC2    | 1   | 0.00| 0.14 | 0.35              |
| EDUC3    | 1   | 0.00| 0.07 | 0.25              |
| SEASON   | 1   | 0.00| 0.27 | 0.45              |
วิเคราะห์ผลการวิจัย

ประสิทธิภาพการผลิตข้าวของเกษตรกรในภาคเหนือ
ตอนบน พบว่าเกษตรกรส่วนใหญ่มีประสิทธิภาพอยู่ในระดับมากถึงมากที่สุด โดยเกษตรกรผู้ปลูกข้าวด้วยวิธีนาดามมีประสิทธิภาพมากกว่าการปลูกข้าวด้วยวิธีนาหว่าน
ส่วนปัจจัยที่มีผลต่อการเลือกบริการการผลิตข้าว
พบว่าประสบการณ์การผลิตประกอบไปด้วยจำนวนสมาชิกในครัวเรือนภาคการเกษตร และเงินลงทุนส่วนตัวมีผลต่อประสิทธิภาพการผลิตในเชิงบวก ซึ่งสอดคล้องกับผลงานการศึกษาของ Nyemeck et al. (2001) และ Battese et al. (1996) สำหรับที่ในภาคผลิต และระดับการศึกษาของผู้ผลิตมีผลต่อประสิทธิภาพการผลิตในเชิงลบ ซึ่งสอดคล้องกับผลงานการศึกษาของ Omonona et al. (2010) และ Ben (2000)

สรุปผลการวิจัย

แม้ว่าผลการศึกษาจะแสดงให้เห็นว่า ระดับประสิทธิภาพการผลิตของเกษตรกรในพื้นที่ภาคเหนือ
ต่ําเกินไปเป็นจำนวนน้อย แต่ยังคงมีการใช้ปัจจัยการผลิต สะท้อนให้เห็นว่าไม่ได้มีความคุ้มค่าเท่าใดนัก เนื่องจากเกษตรกรส่วนใหญ่ยังขาดองค์ความรู้การบริหารจัดการด้านการผลิต ถือว่าเพื่อให้เกิดการใช้ทุนการผลิตในระดับต่ําที่สุด จึงจำเป็นต้องทำการปรับลดปัจจัยการผลิตลงโดยเฉพาะเกษตรกรผู้ปลูกข้าวด้วยวิธีนาหว่าน ดังนั้นจึงเป็นอิสระที่จะให้เกิดแรงงานจ้างและใช้สารเคมีเป็นส่วนใหญ่ สำหรับการเลือกการผลิตแบบนาดามส่งผลทำให้เกิดประสิทธิภาพการผลิตเพิ่มสูงขึ้น และสามารถลดต้นทุนการผลิตได้ นอกจากนี้เกษตรกรยังมีปัญหาเครื่องมือทางการเกษตรที่มีขนาดใหญ่และมีราคาแพง ซึ่งไม่เหมาะสมกับขนาดพื้นที่ในการผลิต ทำให้ต้องใช้การจ้างเหมาจ้างทำเพื่อเกิดต้นทุนที่สูงปานกลางแต่ละรอบการผลิต เพราะจากเกษตรกรมีเครื่องมือทางการเกษตรที่เหมาะสมเป็นของตนเอง จะทำให้มูลค่าต้นทุนคงที่โดยเฉลี่ยในแต่ละรอบการผลิตลดลงได้

ดังนั้น หน่วยงานที่เกี่ยวข้องกับการเกษตร เช่น สหกรณ์การเกษตร หรือส่วนราชการจังหวัดควรเข้ามาให้คำแนะนำในการใช้ปัจจัยการผลิตอย่างเหมาะสม เพื่อลดปัญหาขาดทุน หรือได้ผลตอบแทนไม่คุ้มค่ากับ
ต้นทุนที่เสียไป ส่วนเกษตรกรควรส่งเสริมให้สมาชิกในครัวเรือนหันมาทำนาด้า เพื่อเพิ่มโอกาสในการผลิตและได้รับผลตอบแทนเพิ่มสูงขึ้น นอกจากนี้เกษตรกรควรให้ความสำคัญกับการจัดทำบัญชีครัวเรือนมากขึ้นเพื่อทราบรายการผลิตภัณฑ์ที่เกินความจำเป็น และจะได้รับผลสัมฤทธิ์หล้งกับขนาดพื้นที่ของตนเอง ดังนั้นในการศึกษาครั้งต่อไป ควรมีการพิจารณาลดปัจจัยการผลิต เช่น การใช้ปุ๋ยแยกรายชนิดเพื่อความชัดเจนของต้นทุน รวมถึงการวิเคราะห์ประสิทธิภาพเพิ่มขึ้นระหว่างข้าวอินทรีย์และข้าวเคมีในแต่ละพื้นที่ในการผลิต

กิตติกรรมประกาศ

บทความนี้เป็นส่วนหนึ่งของการวิจัยเรื่องประสิทธิผลการผลิตข้าวตามวิธีเขตกรรมระหว่างนาด้าและนาหว่านของเกษตรกรในเขตภาคเหนือตอนบนได้รับการสนับสนุนจากโครงการส่งเสริมการวิจัยในด้านศึกษาและพัฒนาผลิตภัณฑ์ทาง自然科学ได้สำนักงานคณะกรรมการอุดมศึกษา ประจุปีงบประมาณ พ.ศ. 2559

เอกสารอ้างอิง

กองแผนงานและวิชาการ. 2554. ค่านวมการทำการนาหว่านข้าวในไทย. กรุงเทพฯ:กรมวิชาการเกษตร. 170 หน.

เจเจน จันทร์ประเสริฐ. 2518. การวิเคราะห์เศรษฐกิจการทำการนาหว่านข้าวในประเทศไทย ปี 2515-2516. วิทยานิพนธ์ปริญญาโท. มหาวิทยาลัยเกษตรศาสตร์. 98 หน.

ธนาคารแห่งประเทศไทย สานักงานภูมิตะวันเฉียงเหนือ. 2556. แรงงานกับการเปลี่ยนแปลงของภาคเกษตรไทย. [ระบบออนไลน์]. แหล่งที่มา https://www.bot.or.th/Thai/MonetaryPolicy/NorthEastern/DocLib_Research/04Laborwith%20Agri%20Changing.pdf. (10 กันยายน 2558).

Battese, G.E., S.J. Malik and M.A. Gill. 1996. An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. Journal of Agricultural Economics 47: 37-49.

Ben-Belhassen, B. 2000. Measurement and Explanation of Technical Efficiency in Missouri Hog Production. Selected paper. p. 8-12. In Annual Meeting 30 July–2 August. Tampa: American Agricultural Economics Association (AAEA).

Coelli, T. and G. Battese. 1996. Identification of factors which influence the technical inefficiency of Indian farmers. Australian Journal of Agricultural Economics 40: 103-128.

Nyemeck, J.B., K. Sylla and I. Diarra. 2001. Analyse des Determinants de la Performance Productive des Producteurs de Cafe Dansune Zone a Faiblerevenu en Cote Divoire. Nairobi: Final Report, AERC. 51 หน.

Omonona, B.T., O.A. Egbevtokun and A.T. Akanbi. 2010. Farmers resource use and technical efficiency in cowpea production in Nigeria. Econ. Anal. Policy 40: 1-5.