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Benchmarking and prospecting of technological practices in rice production

(Penanda aras dan prospek amalan teknologi dalam pengeluaran padi)

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Keywords: benchmarking, prospecting, technological practices, rice production, Malaysia, Vietnam

Abstract

The objectives of this study were to benchmark and compare rice production technology in Malaysia and Vietnam and to prospect potential technology that is suitable to be adopted in the local environment. Data were analysed using the Fuzzy Logic method to obtain the index of rice production technology. Eight benchmarking parameters based on Rice Check were selected, namely rate of seed, seed preparation, soil preparation, tillage, water management, fertilisation, weed management and, pest and disease management. The study found that the majority (65%) of farmers in Malaysia are on the average level of the technology index, while 60% of farmers in Vietnam are at the best level. The Fuzzy Logic analysis found that the overall technology index of rice production in Malaysia (0.52) was lower than Vietnam (0.56). There was also a huge gap between the best and the worst technological practices in Malaysia, while on the other hand, the gap was smaller in Vietnam. It revealed that the disparity of technological practices in rice production among farmers in Malaysia is still low compared to Vietnam. Therefore, self-initiative, better training and effective technology transfer programme are needed by Malaysian farmers for impactful technological adoption.

Introduction

Rice is a staple food among Malaysians. At present, Malaysia is still dependent on import at about 30% of total consumption from other countries. Various efforts and government interference in the paddy and rice industry have been made to ensure the food security and farmer's welfare.

The increasing rate of productivity in the industry is due to the change in technology. The factors of production such as labour, capital and others are contributed directly to the increase of farm productivity. Besides that, innovation is also an important factor in increasing the productivity and competitiveness in the long term. The introduction of new technologies could increase yield and farmers' income, which is in line with the Economic Transformation Programme (ETP) announced by the Prime Minister to achieve high income country.

Technological interventions, largely through mechanisation and introduction of modern rice varieties, are considered the key factors that contribute to Malaysia's increasing rice yields. Therefore, there is a need to identify and benchmark the level of rice production technology practices among

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farmers in Malaysia. The objectives of this study were to benchmark and compare rice production technology in Malaysia and Vietnam and to prospect potential technology that is suitable to be adopted in the local environment.

Overview of rice industries in Malaysia

Rice is a highly protected food crop and strategically important industry in Malaysia economic development. Rice cultivation has been given a high emphasis in government policy to ensure there is sufficient supply of rice in the country. The annual growth rate of paddy production is 1.47%. Rice production increase from 1.88 tonnes in 1990 to 2.63 tonnes in 2013 (*Figure 1*). Average annual yield has consistently increased from 2.769 t/ha in 1990 to 3.820 t/ha in 2013 despite the fluctuating trend in harvested area from 680,647 ha to 688,207 ha during the 1990 – 2013 period. A significant decrease of 6.9% in rice self-sufficiency level (SSL) was recorded from 1990 (78.6%) to 2013 (73.5%). Consequently, the rice import has considerably increased from 330,336 tonnes in 1990 to 876,100 tonnes in 2013.

The rice import in 1990 was valued at RM2,69.7 million and increased to RM1.5 billion in 2013 with annual growth rate at 7.18% (*Figure 2*). The main suppliers of imported rice were Thailand and Vietnam followed by Pakistan, Australia and China.

Paddy production is largely concentrated in the eight major granary areas: Muda Agricultural Development Authority (MADA) in Kedah and Perlis, Penang Integrated Agricultural Development Project (IADP Penang), North West Integrated Agricultural Development Project in Selangor (PBLS), Kemubu Agricultural Development Authority (KADA) and Kemasin Semerak Integrated Agricultural Development Project in Kelantan, KETARA Agricultural Development Authority (KETARA) in Terengganu, Kerian Integrated Agricultural Development Project and Seberang Perak Integrated Agricultural Development Project in Perak.

In terms of average yield, PBLS and MADA are the highest performers (*Table 1*). The issue of productivity has been discussed by various parties, such as plant scientists, agricultural economists and policy makers. Granary areas have higher potential in productivity improvement compared to others.

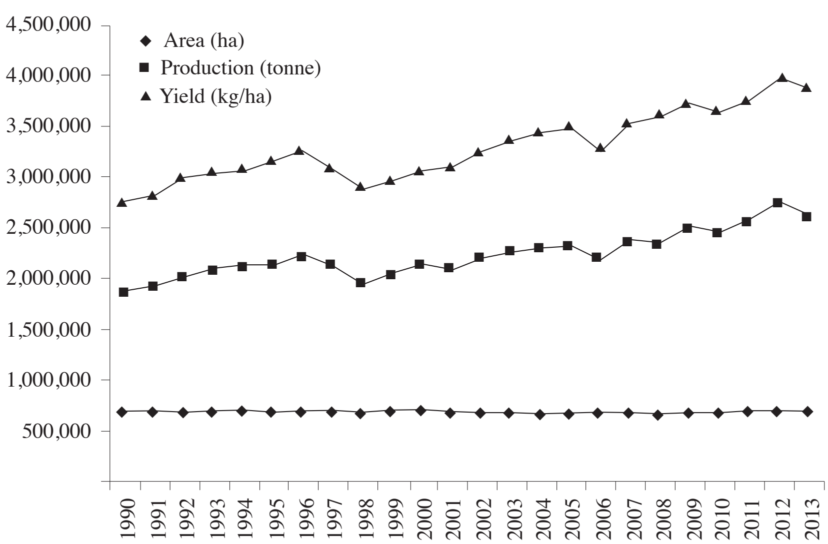

Figure 1. Area, production and yield of paddy in Malaysia (1990 – 2013)

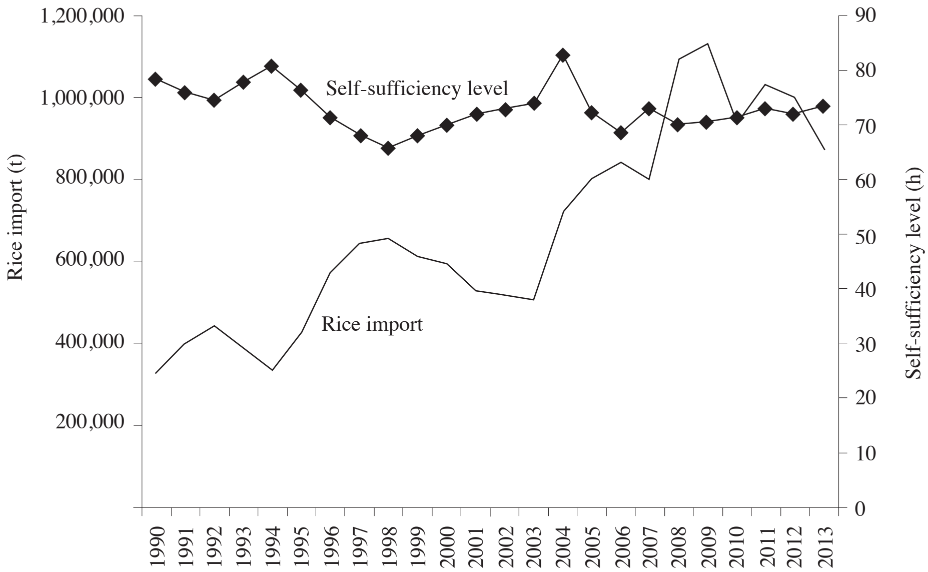

Figure 2. Rice import and self-sufficiency level (1990 – 2013)

Table 1. Area, production and yield by granary and non-granary area (2013)

Area	Area (ha)	Production (kg)	Average yield (t/ha)
MADA	187,413	941,889	5.026
KADA	38,641	159,800	4.136
PBLS	37,833	237,594	6.280
IADA Kerian	41,955	188,586	4.495
IADA Pulau Pinang	20,610	120,383	5.841
IADA Seberang Perak	27,686	126,027	4.552
KETARA	9,752	54,114	5.549
IADA Kemasin Semerak	5,383	18,815	3.495
Granary (total)	369,273	1,847,208	5.002
Non granary (total)	131,817	395,998	4.440

Source: MOA (2013)

The growth rate of rice cultivation area is 1.11% for a period of 23 years from 1990 to 2013 with yield increment at 1.65% per annum. Furthermore, the cost of rice production in Malaysia is the second highest in Southeast Asia after Indonesia.

Rice production in Vietnam

The rice production in Vietnam is concentrated in the Mekong Delta, where it accounted for 50% of national production. Vietnam is the fourth producer country that supplies rice to many countries in the world with 90% of its exports are from the Mekong Delta. Total rice production in Vietnam was 42.3 million tonnes in 2013 with an area of 7.6 million hectares (*Table 2*). The average yield for the whole of Vietnam is 5.53 t/ha and this is the highest productivity in Southeast Asia.

Paddy farmers in Vietnam are using Rice Check Programme from Australia that was modified in 2002 under the name "3 increases, 3 reductions" Tropical Rice Check. The programme was then improved to rice production model known

Table 2. Average rice production and yield in Vietnam (2013)

Region	Production (mill tonnes)	Area harvested (mill ha)	Yield/ha
Mekong Delta	20.5	4.1	5.29
Vietnam	42.3	7.6	5.53

Source: FAO (2013)

as the 1M-5R. 1M means farmer must use certified seed and 5R means farmers have to reduce the consumption of seeds, pesticides, fertilisers, water and postharvest loss. Rice was cultivated in Vietnam in three seasons a year with different disease control techniques for each season.

Farmers in Vietnam do not receive any subsidy from the government. The Vietnamese government gives support in terms of incentives through training programmes. Among the government programmes are:

1. Farmers strengthening
    - Farmers Agricultural Research and Extension System Partnership (FARES). Breeding research focuses on development of rice varieties.
2. Farmers Field School (FFS)
    - Farmer training school on empowerment of farmers.
3. Seed Club Network
    - Club network enables seed producers and farmers make the choice of developing its own seed.

In addition, the Vietnamese government also provides interest free loan at 50% of the purchase price of the farm machinery such as harvesting machines, tractors, plows and other. This incentive is to encourage farmers in Vietnam to have their own machinery.

Technological practices

The technological practices among farmers in Malaysia are based on the manual of rice production, published by MARDI and Rice Check. Rice Check is a recommended technology package with complete standards for compliance and is important as a guide for farmers to achieve 10t/ha. The 10 key checks which must be followed by farmers to achieve 10t/ha are:

1. Measurement of land acidicity (pH)
2. Land preparation
3. Rouging weedy rice
4. Irrigation schedule
5. Ploughing
6. Planting/seeds
7. Fertilising
8. Water management
9. Weed, pest and disease control
10. Harvesting

Rice farmers must follow the key Rice Check to manage rice plants as targeted. Every single check must be fulfilled by rice growers to achieve high yields. Field monitoring in terms of growth, water management, fertilisation, weed and pest control, and harvesting is important to identify problems and actions that should be taken to solve the problem. This record is essential to guide farmers for the next season, so that the same problem does not occur.

Literature review

Benchmarking is always used in evaluating the performance of business, firm or organisation. The process or method to benchmark may be different according to industry and desired target. Benchmarking study in Malaysia is still infrequently applied to the industry compared to other countries.

There are many definitions related to the word 'benchmark' elaborated by researchers. Benchmarking is a systematic and continuous process to identify, study, modify and implement the best practices from the same organisation or from other organisations to achieve the best performance (Kahan 2010). Benchmarking, in its proper process-based form, is about what things are done on farm, how they are done and what are the consequent productivity and financial outcomes (Ronan and Cleary 2000).

Benchmarking requires one to choose the measurements with the best performance and to reduce any gaps that exist. Generally, it involves the agency to review best practices committed by the other party, how it is done and how the agency can do it better. In this process, the agency will make a comparison with the best performers to improve a product or service or process work. It is a tool to identify and achieve a standard of excellence.

Many benchmarking studies focused in farm operations, farm performance, productivity and outcomes. Benchmarking indicator also refers to technical aspect or process to achieve target yield and profit. Benchmarking also can lead to increased productivity and profit and to improved efficiency in the farm business. Ten basic steps were used in the benchmarking process to evaluate the performance of farm business (Kahan 2010).

The benchmark indicators that have been used to evaluate the farm performance are general indicator (climate, land, cropping intensity, soil quality, water and irrigation management), crop characteristics (varieties, quality and source of seeds, crop rotation), production operations (pre planting, fertiliser use, weed control, pest and diseases, irrigation, crop growth, harvesting, machinery). Some indicators in post production operations such as postharvesting, marketing and economics were also used in the study. The indicators selected can describe all aspects of the farming system. Data were analysed to compare the performance of every single farm through identifying the differences or gaps within farms. The differences should indicate the strengths and weaknesses of the respective farming system and identify the best and worst performance among farms.

According to Kale and Karaman (2011), benchmarking method is one of the most powerful performance modelling approaches. This modelling provides a systematic framework for identifying, classifying, and evaluating firms' processes, activities and performances.

Krajnc and Glavic (2007) used the FL model to compare the performance of traditional sugar beet plants in Slovenia. In their study, the FL model, which was based on fuzzy set theory, was conducted to compare the performance of plants within a sector's best standards. They used a linguistic fuzzy set to express the performance defined by the indicator, using word expressions such as low, medium, high, etc. depending on the value of the indicator.

Methodology

This study was conducted using primary and secondary data. Secondary data were obtained from journal articles, books, magazines and news articles. Secondary information obtained from the Department of Agriculture and eight granary areas namely MADA, IADA Penang, PBLS, KADA, IADA Kemasin Semerak, KETARA, IADA Kerian and IADA Seberang Perak.

The primary data were obtained from a survey conducted on 268 rice farmers in the granary and non granary areas in Malaysia as well as five groups of farmers in five different areas in the Mekong Delta, Vietnam. Respondents were selected using stratified sampling method based on high, average and low yield categories of farmers. Vietnam was chosen because it has the highest productivity in Southeast Asia with the same weather as Malaysia. Besides that, the production cost in Vietnam is lower than in Malaysia at USD974.70.

Data were analysed using descriptive statistics to get an initial overview of the data obtained. Furthermore, data were analysed using the Fuzzy Logic (FL) to obtain the indices of rice production technology. The FL model is commonly used by researchers to benchmark the performance of farm or industry. The FL model used in this study was based on the concepts of fuzzy set theory by papers from Kranjc and Glavic (2007) and Kale and Karaman (2011).

In this study, eight parameters of the benchmarking indices based on Rice Check were considered. They were rate of seed, seed preparation, soil preparation, tillage, water management, fertilisation, weed management and, pest and disease management. Each farm parameter was determined based on the quality features which was eventually classified into three categories of status/achievement (worst, average and best).

Fuzzy Logic (FL) analysis was conducted to all technology parameters to determine the technology indices for granary and non granary areas. A fuzzy analysis is one that assigns grades of calculations between 0 and 1 for every technological practice. The classification of farm technological practices level is shown in *Table 3*.

Table 3. Classification of technological practices level according to index score

Index score	Level of technological practices
x ≥ 0.6	Best
0.5 ≤ x < 0.6	Average
x < 0.5	Worst

Results and discussion

Analysis of FL showed that the best technological practices among farmers include fertilising, ploughing and seed rate at 0.77, 0.69 and 0.67 respectively. Meanwhile, the worst technological practices were weed management and seed preparation at 0.40 and 0.42 respectively for all granary areas (*Figure 3*). The index of overall technological practices in paddy production was found at an average of 0.52 which is still at moderate level. The huge technology gap was found in every practice among farmers. Therefore, these findings have shown the role of extension agents could be significant to potentially reduce technology gap which lead to increase in productivity.

Figure 4 shows a spider chart of benchmarking indices in rice production technology in granary and non granary areas. The sketch shows the best technological practices is in PBLS area, followed by MADA and lowest in KADA. Tillage practices, water management, land preparation and seed preparation in the PBLS are the best among the country's rice cultivation areas.

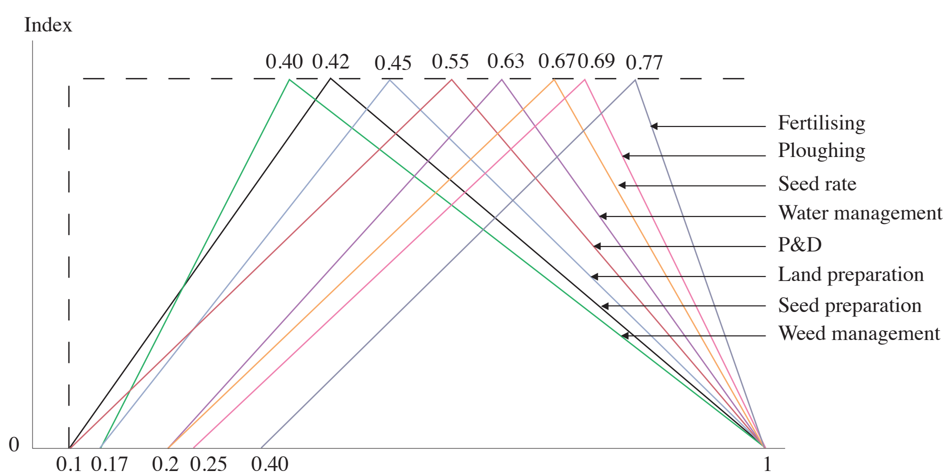

Figure 3. Technology gap by parameters

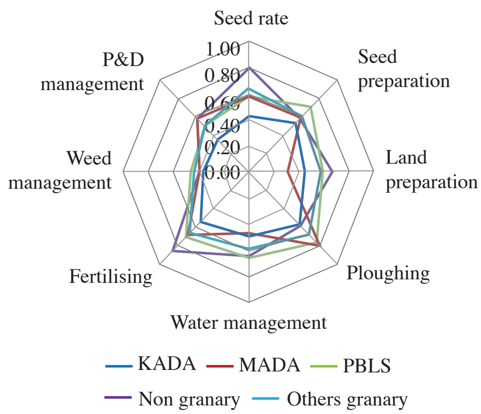

Figure 4. Technology parameters score

Table 4. The level of technological practices among granary and non-granary areas

Area	Best	Average	Worst	Total
KADA	0	33	24	57
MADA	1	41	14	56
PBLS	10	49	17	76
Non granary	6	29	11	46
Others granary	5	23	5	33
Total	22	175	71	268

Fertiliser practices, weed management, pest and disease management, and seed rate in KADA area showed the highest index among paddy growing areas. The reason could be because the level of soil fertility in KADA was low and required more use of fertilisers to enrich the soil and high seed rate to augment the growth of rice seedlings.

The best farmers were 10 farmers in PBLS area, 6 in non-granary area and 5 from other granary areas (*Table 4*). Other granary areas include Seberang Perak, KETARA, Kemasin Semerak, Kerian and IADA Penang. Majority of the farmers (65%) were ranked in moderate level while only 8% of farmers were in the best practices in technological practices and the rest were considered in the worst level.

Further analysis was done to compare the technological practices among granary and non granary areas. Results showed that

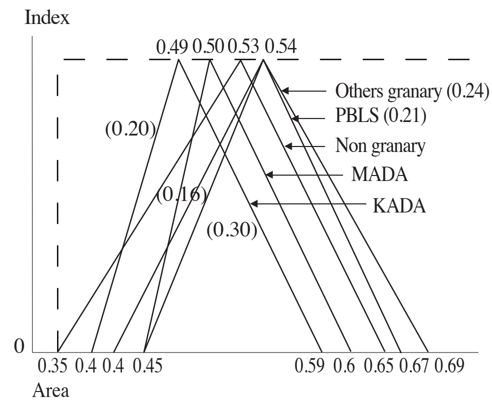

Figure 5. Technology gap by area

the technological indices for PBLS was 0.54, which was higher than the overall average (0.52) (*Figure 5*). Another analysis was also conducted to determine the technology gap among the farms in granary and non-granary areas. It was done by comparing the best and the worst farm technology indices in every area. The lower value of difference would mean that the technology gap was narrower and vice versa. It was found that the technology gap value for MADA was 0.16 which was significantly lower than other granary areas, follow by KADA and PBLS. The technology gap among granary areas was smaller as compared with farmers in non-granary. In other words, the gap between technological practices among farms in non-granary was varied from very traditional methods to more advanced practices in paddy production.

Comparative of rice technological practices between Malaysia and Vietnam

The purpose of this analysis was to compare the benchmark indices in rice production technology between Malaysia and Vietnam. It was also to determine the level of local technology compared to rice production technology in Vietnam and to identify new technologies which are suitable to the local environment, so that the adoption of these technologies can be implemented more effectively. In addition, this comparative analysis would also be able to identify the

Table 5. Comparison of profile of farmers and field between Malaysia and Vietnam

Profile farmers/field	Malaysia	Vietnam
Age	52 years	41 years
Education	Secondary school (60.8%)	Secondary school (100%)
System of rice field	Individual (90%)	Grouping (100%)
Hectarage (ha/farmer)	4.8 ha	1.8 ha
Land ownership	Ownership (27%) Rent (35%) Ownership and rent (34%) Others (4%)	Government
Water management	Irrigation system (77%), water pump (23%)	Irrigation system (40%), water pump (60%)
Maturity periods	95 – 115 days	80 – 100 days
Planting cycle	2 seasons	3 seasons

competitiveness of technology adopted by local industries compared to the best class in the world for further improvement.

The average age of farmers in Malaysia is 52 years old, higher than the average age of farmers in Vietnam which is 41 years old (*Table 5*). Majority of farmers in both countries had only a secondary school level of education. There are differences in rice fields system where the majority of farmers in Vietnam are in the group farming system while in Malaysia individual farmers are common. In terms of acreage and land ownership, farmers in Malaysia have an average area of 4.8 ha/farmer, whereas in Vietnam 1.8 ha/farmer. In Vietnam, all farmers used government land to cultivate rice. Therefore, the government has the power to withdraw the status of ownership of land if the farmer does not achieve a good performance in increment of productivity. This situation could become a threatening factor to farmers as they follow government recommendations in rice production technology. The irrigation system in Malaysia was provided by the government, while the Vietnamese farmers need to use water pumps and gravity for water irrigation in the rice fields. The maturity periods of the varying rice varieties in Vietnam are shorter than in Malaysia which allows three seasons cultivation a year to take place in Vietnam.

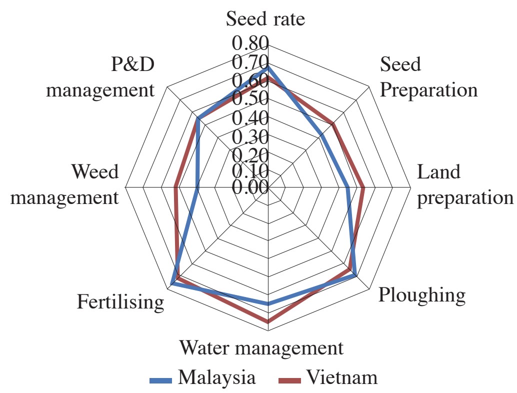

Figure 6. Benchmarking indices between Malaysia and Vietnam

Figure 6 shows a spider chart which illustrates the difference between the benchmarking indices between Malaysia and Vietnam for eight parameters. The chart clearly shows the technological practices of ploughing, fertilising, weed management, pests and diseases in Malaysia are lower than in Vietnam.

Results from fuzzy logic analyses show the overall technology indices of rice production in Malaysia is 0.52, which is lower than Vietnam at 0.56 (*Table 6*). The benchmarking indices in Vietnam is higher than Malaysia for ploughing, fertilisation, weed management, and pest and disease management. The average yield of rice in Malaysia is lower than the

Table 6. Comparative of benchmarking indices between Malaysia and Vietnam

Country/parameters	Malaysia	Vietnam
Benchmarking indices	0.52	0.56
Seed rate	0.67	0.50
Seed preparation	0.42	0.50
Land preparation	0.45	0.40
Ploughing	0.69	0.87
Water management	0.63	0.60
Fertilising	0.77	1.00
Weed management	0.40	0.60
Pest and disease management	0.55	0.60
Yield/ha	6.23	7.16
Return/ha	RM6,853.00	RM4,968.00
Cost/ha	RM3,091.77	RM2,358.00
Profit margin/ha	RM3,761.23	RM2,610.00

average yield of rice in Vietnam at 6.23 and 7.16 respectively. However, the returns to farmers in Malaysia is higher than farmers in Vietnam at about RM1,885.00/ha. This is because the price of rice in Malaysia is much higher than in Vietnam at RM1,200.00/t and the additional government subsidy of RM248.10/t. Besides that, production costs in Malaysia are higher compared to Vietnam at about RM3,091.77/ha and RM2,358.00/ha respectively. Overall, profit margins for farmers in Malaysia is higher than farmers in Vietnam at RM1,151.23/ha.

Results found that the majority (65%) of farmers in Malaysia were in average level of technological practices, only 8% of the farmers were at the best level of technological practices and the rest (27%) were considered at worst level. Meanwhile, 60% of farmers in Vietnam were at the best technological practices level and the rest (40%) were in average level.

There is a huge gap between the best and worst practices in Malaysia and vice versa, but it shows a smaller gap in Vietnam (*Figure 7).* This finding shows that rice production technological practices among farmers in Malaysia are low compared to Vietnam. These results may suggest that the role of the agencies in charge of technology transfer should be strengthened

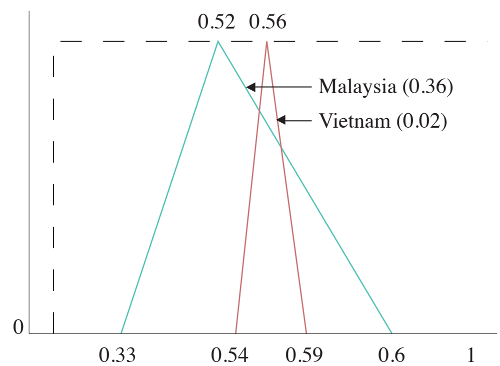

Figure 7. Comparison of technology gap between Malaysia and Vietnam

and enhanced. In addition, the Vietnamese government plays a big role in building the capacity of farmers to improve their efficiency and productivity. Vietnamese farmers also have their own initiatives to establish seeds club that make their own seeds selection to ensure the seed quality. Thus, better self-initiative, training and technology transfer programme are required by the Malaysian farmers for more effective technology adoption.

Prospecting in rice production

The development of paddy and rice industry is highly dependent on the technology innovation. Although the factors of production such as labour, capital and others, contributed directly to increasing rice productivity, technology and innovation are also important factors for increased productivity of rice production and to sustain and improve competitiveness in the long term. Therefore, the benchmarking study that was conducted in Malaysia as well as comparative studies of rice production technology in Vietnam have given some suggestions of new technologies that can be adapted in Malaysia. The prospect of this technology is expected to help the country in increasing the productivity of rice production in Malaysia. Among the technologies that have the potential to be introduced based on the findings include:

i. **Ploughing technology: Land levelling machines with GPS system**
   Land levelling using laser and GPS system is a very effective method before planting. In Vietnam, majority of the farmers use this machine for land levelling activity and it is very impactful in increasing rice production.

ii. **Water management: Water measurement tools**
   Water management is important in rice cultivation to ensure good growth of until harvesting. This tool is used to measure the water level in the fields which is either exceeded or decreased. If the water exceeds, farmers have to push out water from their fields or pour in water if otherwise occurs.

iii. **Weeds, pests and diseases management**
   Farmers in Malaysia are using knapsack sprayer to spray pesticides. These spray tools only cover a small area with a single spray. Innovation of spray tools which are more efficient and effective is needed to reduce the effect of pesticides to farmers and also reduce cost and save time. In Vietnam, farmers use a long sprayer to spray pesticides, and this can increase the spray area, reduce the effects of spraying to farmers and also save time.

iv. **Harvesting machine**
   Farmers in Malaysia are using combined harvester machines which were modified from Holland for harvesting rice. Majority of the rice fields have no hard pan which would cause a problem when using a big combined harvesting machine. In addition, many farmers use service providers for rice harvesting as they were not able to buy the costly harvesting machines. Therefore, there is a need for technological innovation for harvesting machines that are smaller and lighter to overcome the problem of land hard pans in Malaysia. Harvesting machines in Vietnam are smaller and cheaper compared to the existing harvesting machine in Malaysia. It is also more efficient with lower price at USD23.524/unit. The Vietnamese machines provide an opportunity for farmers in Malaysia to be able to have their own machines.

Conclusion and recommendation

The technological practices for paddy production in Malaysia are still in moderate level at 0.52. However, the overall benchmarking indices in PBLS were relatively better than other granary and non granary. There was a huge gap between the best and the worst technological practices for paddy. It was also revealed that the technological practices in rice production among farmers in Malaysia could be improved with more intensive technology transfer programme by extension agents. Strengthening and enhancing the extension role could give a significant impact in technology adoption among producers. Besides that, farmers also need self-motivation and interest in the application of the best practices in paddy production. Therefore, self-initiative, better training and effective technology transfer programme are needed by Malaysian farmers for impactful technological adoption.

Comparative analysis found that the majority (65%) of farmers in Malaysia are at average level of technology index, while 60% of farmers in Vietnam are at their best. Benchmark indices of rice production technology in Malaysia are lower than Vietnam (0.56). There is a huge gap between best practices and best technologies in Malaysia, compared with distinction Vietnam's technological practice which has smaller technology gap. This shows that rice production technological practices among farmers in Malaysia still need to be improved to bridge the huge technology gap compared to Vietnam.

These findings also suggest that the role of the agencies in charge of technology transfer should be strengthened and enhanced. The Vietnamese government plays a big role in building the capacity of farmers to improve their efficiency and productivity. In addition, Vietnamese farmers also established seed production teams who choose their own seeds to ensure the production of quality seeds.

This finding is important in responding to which technology should be improved to increase the country's rice production. It is also important to farmers and all the players in the country's rice industry to enhance the productivity and income of farmers. The benchmarking indices for rice production technology can be used as a guideline for policy makers to improve existing technologies or generate new technologies which are appropriate to the needs of farmers and the country's rice industry. The findings can also be used by development agencies to develop programmes so that technology adoption among farmers is more efficient.

In addition, the development officer role is important in the technology transfer programme to target groups. Therefore, programme with more intensive technology transfer should be implemented to provide a greater impact on farmers in the practice and use of technology. Farmers also need to be more self-motivated and committed in implementing best practices in rice production technology. Farmers who practice the best technology can be used as a role model to other farmers who are still at low levels of achievement. This is to ensure that the best technological practices knowledge is known to all farmers to bridge the technology gap among them.

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Abstrak
Objektif kajian ini adalah untuk menanda aras indeks teknologi pengeluaran padi dan memprospek teknologi baru yang boleh diterima dan disesuaikan dengan persekitaran di Malaysia. Data dianalisis dengan menggunakan kaedah Logik Kabur (*Fuzzy Logic*) untuk mendapatkan indeks teknologi pengeluaran padi. Lapan parameter indeks tanda aras telah dipilih berdasarkan *Rice Check* iaitu kadar benih, penyediaan benih, penyediaan tanah, pembajakan, pengurusan air, pembajaan, pengurusan rumpai dan pengurusan perosak dan penyakit. Kajian mendapati bahawa majoriti (65%) daripada petani di Malaysia berada pada tahap purata indeks teknologi, manakala 60% daripada petani di Vietnam berada pada tahap yang terbaik. Analisis Logik Kabur mendapati bahawa indeks teknologi keseluruhan pengeluaran padi di Malaysia (0.52) adalah lebih rendah daripada Vietnam (0.56). Terdapat juga jurang yang besar antara amalan teknologi yang terbaik dan paling teruk di Malaysia dan sebaliknya, didapati jurang perbezaan adalah lebih kecil di Vietnam. Ini menunjukkan bahawa amalan teknologi pengeluaran padi dalam kalangan petani di Malaysia masih rendah berbanding dengan Vietnam. Oleh itu, inisiatif diri, latihan yang lebih baik dan program pemindahan teknologi yang cekap diperlukan oleh petani Malaysia untuk penerimaan teknologi yang lebih berkesan.