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COMPARISON BETWEEN TISSUE CULTURE AND CONVENTIONAL BANANA SAPLING

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ABSTRACT

This study was conducted to compare between banana farmers that used tissue culture technique sapling with conventional. Information from 68 farmers consisting of 59% tissue culture and 41% conventional in major banana production zone in Johor and Perak were used in this study. Analysis showed that the cost of productions in conventional farming (RM3,850 per acre) was 45% higher than in tissue culture (RM2,664 per acre). The cost of seed and insecticide were significantly different between both techniques. The cost of seed and insecticide for tissue culture technique were 33% and 87% higher as compared to conventional, respectively. However, fuel consumption in conventional was 134% higher than tissue culture technique. Farmers' average net income in tissue culture technique sapling (RM4,641) was slightly higher than conventional farmers (RM4,191). Analysis also found that the average TP (total productivity) and TE (technical efficiency) were higher for farms that using tissue culture technique sapling. Cobb-Douglas regression analysis showed that land, labour and sapling were the important factors which determined the production of banana. In general, the use of tissue culture technique sapling in banana plantation should be encouraged to enhance and increase the country's banana production.

Keywords: *total productivity, technical efficiency, banana, tissue culture.*

INTRODUCTION

Tissue culture is a technique of producing saplings by using a selected plant tissue from the leaf, stem or cell multiplied in vitro into a nutrient medium solution. Tissue culture technique, well-known as micro propagation allows multiplication of uniform and high quality plant clones since they inherit the properties of the parent plant physically and genetically. The production of more saplings in a short period of time without the process of pollination and seeds, healthy, virus-free and uniform are the integral factors in improving the level of management efficiency in the planting system. Uniform growth and almost simultaneous maturity will facilitate harvesting management, improve the quality of the product and help in estimating a better output estimation. Therefore, production and marketing will become more systematic [1]. Mbogoh (2002) in his study suggested that these benefits should present when using tissue culture technique:

i. Availability of large quantities of clean and superior planting material;
ii. Substantial reductions in the yield losses from pests and diseases through the promotion of good farm hygiene practices and proper management for the crop;
iii. Additional advantages accruing from the superiority of the planting material in terms of its early fruiting and maturing period, bigger bunch weights, and a higher annual yield per unit of land; and
iv. Easier coordination of marketing due to more uniform and simultaneous plantation development [2].

At Malaysian Agricultural Research and Development Institute (MARDI), researches on banana sapling production through tissue culture technique started in the early 1980s by researchers at Central Research Laboratory, Biotechnology Unit. After successful lab researches, in-farm implementation assessments were conducted by the scientists at Horticulture Research Centre. In the 1990s, the technology of banana sapling production using tissue culture technique was disseminated through research and poster presentations as well as courses conducted for farmers, entrepreneurs and others. In 2006, the commercialization of tissue culture banana sapling production was handed to researchers at Planting Material, Seed and Livestock Breed Production Unit located at Jalan Kebun MARDI station. The production showed an increase from 1,220 saplings in 2006 to 41,489 saplings in 2009. However the production was decreased to 37,214 saplings in 2010 due to lower demand. In 2010, tissue culture banana sapling production by MARDI was awarded the MS ISO 9001:2008

certificate. This certification assured the quality of tissue culture produce by eliminating the saplings that do not comply with standard in every stages of production process.

MARDI could produce substantial amount of saplings in a short term with a target of 30,000 saplings per annum. The advantages of MARDI's tissue culture banana sapling include uniformity of in-farm growth with an average height of seven feet, to facilitate the process of harvesting. The trees started fruiting in six to seven months after planting, shorter than conventional sapling. Moreover, the yield was more consistent and each planted trees could be productive in three generations / rotations. MARDI's saplings were guaranteed to have the same quality as the parent tree in terms of health and diseases-resistance. The saplings were also free from infectious microorganisms as high measure of security is practised in the laboratory during production [3].

In the National Key Economic Area (NKEA) agenda, among the government target was to increase the production of high quality fruits that are also in accordance with food safety standards. Banana was one of the chosen commodities based on its local strength in production and global demand [4]. This could be achieved by increasing farm's productivity and efficiency other than larger plantation areas. As a result, a large quantity of saplings is needed particularly those productive and disease-resistance. Larger scale of production would also mean an increase of input materials mainly, fertilizers and pesticides. However, by using tissue culture technique, it was evident that using a high quality tissue culture sapling can overcome the issues of high requirement of such input materials thus increasing farm income.

Even though the advantages of using tissue culture sapling are already well known, some farmers are reluctant to use it since the cost of purchasing tissue culture saplings are higher than conventional saplings. The tissue culture sapling introduced to replace conventional sapling must satisfy the needs and desires of the farmers (technology users) while being cost-effective. Graff (2000) in his study, argue that when a farmer could obtain only M units of currency (such as dollars) as net returns to a farm enterprise that employs the new technology, adoption might not be feasible unless $M > W + C_1$, where C_1 is the production cost associated with the new technology and W is the extra seed cost, even if the new technology was more desirable [5]. Although tissue culture technique was no longer considered as a new technology, the usage of tissue culture saplings in the farm was generally low.

This research was conducted to study the difference of cost of productions and to compare the total productivity (TP) of farm using tissue culture saplings with those using the conventional sapling. This study also identified the technical efficiency (TE) of banana plantations according to type of saplings used and the socioeconomic and technical factors that affects productivity. This study proposed some recommendations to further increase the acceptance of banana saplings tissue culture technique in the country.

METHODOLOGY

Data resources and sampling

This study uses primary and secondary data capture. Respondents were chosen using stratified random sampling and purposive sampling by choosing banana farmers using tissue culture saplings or conventional saplings at major banana-producing districts. Secondary data were obtained from the Department of Agriculture's statistics on states and districts level that had commercial production of banana.

Structured questionnaire form was used in capturing data from respondents. It includes farmers' profile, profile of farms, production cost, yield and return. Survey was conducted through in-depth interview with farmers. The total of respondents was 68 whom 41% were conventional sapling farmers and 59% were tissue culture saplings farmers. Of that amount, 42 were from Johor, 22 were from Perak while the rest were from Selangor and Pahang (Table 1).

Table 1: Respondents according to states

State	Sapling Type		Total
	Conventional	Tissue Culture	
Johor	17	25	42
Perak	10	12	22
Pahang	0	2	2
Selangor	1	1	2

Cost and return analysis

Banana farmers' income estimates were obtained from cost and return analysis of their production operations. Data from the survey were analysed using the formulas in Table 2.

Table 2: Cost and return analysis formulas

Analysis	Formula
Gross Income	Yield x Price
Total Production Cost	Main Input Cost + Labour Cost + Other Cost + Depreciation
Net Income	Gross Income – Total Production Cost
Main Input Cost (Direct Cost)	Costs of seeds, fertilizers, pesticides, herbicides
Other Costs (Indirect Cost)	Costs of water, electric, petrol / diesel
Depreciation	Vehicles, buildings, machines, irrigation

Productivity analysis

Productivity is related to total output and total resources used during production processes. It was the measurement of the transformation of input materials into output based on the model below:

$$TP = \frac{Output}{Input} = \frac{\Sigma P_i Q_i}{\Sigma p_{ij}.q_{ij}}$$

Where,
TP = total productivity; i = banana farmers, i = l....n; j = input, j = l....m; P = output price; Q = output quantity; p = input price; q = input quantity [6].

Technical efficiency analysis

The concept of efficiency has evolved through the years especially with the advent of dual approach in analyzing production technologies and systems. Some economist had explained the concept and differences among economic efficiency, technical efficiency and price or allocative efficiency. A firm is technically efficient if it produces a higher level of output as compared to another firm at the same level of inputs. It is said to be allocative or price efficient if it maximizes profit by equating the price of each variable input to its marginal product. When both of them jointly occur, there is a sufficient condition for economic efficiency to exist.

The technical efficiency (TE) method used in this study measures the highest potential production from a combination of inputs. The TE measurement model with stochastic frontier production function was applied using either Cobb-Douglas or Translog production function, based on data compatibility. The model using the Cobb-Douglas production function is as follows:

$$\ln Y_i = \beta_o + \beta_i ln X_{ij} + \varepsilon_i$$

Where,
Y = output quantity; X = production factor; β = estimated parameter; i = l....n, farm sample count; j = l....m, production factor count; ε = error, $\varepsilon = V_i - U_i$ [7]. The stochastic frontier production function estimation used maximum-likelihood estimation (MLE) whereby V and U can be estimated by maximising the log-likelihood function [8].

RESULTS AND DISCUSSIONS

Socioeconomic and farm profile

Appendices 1 and 2 show a summary of the farms and respondents' backgrounds. The majority of farmers were between 41 - 60 years old and were full-time farmers with both were about 68% of the respondents. 50% was either degree / master's degree holder, while 34% finished high school. Only 24% had less than 8 years of experience in banana farming.

This study was focused on two varieties of banana: Berangan (70%) and Tanduk (24%). Most farmers who used conventional sapling had less than 6 acres (82%) while only 5 farmers had more than 10 acres of farms (18%). Those who used tissue culture sapling however were more varied in terms of farm area. Analysis showed that 13 farmers (33%) had farms between 8 - 10 acres and 10 (25%) had 2 - 4 acres of farms. 65% worked on their own land while the rest were renting or operating on leased land.

The majority of tissue culture sapling farmers (50%) produced yield at the range of 2 – 6 tonnes per annum followed by 30% produced 6 – 10 tonnes per annum and 13% produced less than 2 tonnes per annum while 8% successfully produced more than 10 tonnes per annum. Meanwhile, 57% of conventional farmers produced yield at the range of 2 – 6 tonnes per annum followed by 18% produced 6 – 10 tonnes per annum and 14% produced less than 2 tonnes per annum while 11% of them successfully produced more than 10 tonnes per annum.

The majority of tissue culture sapling farmers (43%) earned a net income from banana planting in a range between RM2,000 – RM6,000 per annum followed by 31% earned more than RM6,000 per annum and 20% earned less than RM2,000 per annum while 8% recorded a loss. In terms of those who used conventional sapling, 39% grossed at the range of RM2,000 – RM6,000 per annum while both who earned more than RM6,000 per annum and less than RM2,000 per annum category recorded 18%, respectively while 25% of respondents recorded a loss. The average price of banana sold was in the range of RM1.00 – RM1.40 per kilogram.

Income and cost analysis

Appendix 3 shows the statistics of costs involved in banana production. Direct cost included input used i.e. fertilizers, seeds, herbicides and pesticides. On average, direct cost per season for farms that used tissue culture sapling was RM1,233 per acre with a range between RM638 – RM2,277. The highest direct cost was seeds with an average of RM514 per acre and in the range of RM200 – RM975. Relatively, the average direct cost per season for farms that used conventional sapling was RM1,215 with a range between RM447 – RM2,504 per acre. Fertilizers were the highest direct cost with an average of RM471 per acre with high ranged, between RM1 – RM985.

This study found that banana production regardless of types of sapling was still depending on labour. The labour cost averaged at RM1,634 per acre and ranged between RM297 – RM6,955 for conventional farms while for tissue culture farms, the average was RM866 per acre and ranged between RM77 – RM2,163. Other costs included water, electricity and petrol / diesel usage. On average, this indirect cost for tissue culture farms was RM161 per acre with petrol / diesel was the highest (RM87 per acre), while indirect cost for conventional farms averaged at RM999 with electricity was the highest (RM750 per acre).

The capital cost in banana production was consist of farm's assets i.e. vehicles, buildings, machineries and irrigation. In the cost analysis, the fixed cost was calculated by depreciating each assets taking into account of their life cycle. The average depreciation per annum for tissue culture farms was RM556 per acre with vehicle depreciation being the highest component (RM279), while for conventional farms, depreciation averaged at RM658 per acre with vehicle depreciation also being the highest component (RM275).

Total production cost is the sum of all the costs involved in production. This study found that the average total production cost for conventional farms (RM3,850 per acre) was 31% higher than the average total production cost for tissue culture farms (RM2,664 per acre). Comparative test showed that total production cost per acre for both categories were significantly different (Table 3).

This study also showed that there were three components that had a significant difference between both types of systems i.e. costs of seeds, pesticides and petrol / diesel. Costs of seeds and pesticides for tissue culture farms were 32% and 87% higher when compared to conventional farms, respectively. However, petrol / diesel cost for conventional farms was more than 100% higher compared to tissue culture farms. The total cost per acre for tissue culture sapling farms was lower compared to conventional farms, although high cost incurred for seeds and pesticides.

The average net income per season (excluding farms that recorded losses) for tissue culture farms was RM4,641 with a range between RM53 - RM15,122, while the average for conventional farms was RM4,191 with a range between RM757 - RM11,199. Even though the net income for tissue culture farmers was higher, comparative analysis did not show any significant difference.

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Table 3: Average production cost and net income according to types of sampling.

Variable	Type of Sapling		Total	
	Conventional	Tissue Culture		
	Min (RM)	Min (RM)	Min (RM)	
Total Cost (RM per acre)	3,849.64	2,663.68	3,093.08	*
Seed	387.03	514.23	468.18	*
Pesticide	62.74	118.43	98.26	**
Petrol / diesel	204.00	87.10	129.42	**
Net Income	4,191.22	4,640.65	4,477.93	

* significant difference at p=10% using t-test
** significant difference at p= 5% using t-test

Productivity analysis

Total productivity (TP) was calculated by dividing the total return with the total costs involved within the operating period. The average TP for conventional farms was 2.62 with a range of 1.14 - 5.79. The average TP for tissue culture farms was 3.35 with a range of 1.01 - 11.41 (Appendix 4). Table 4 shows TP level scale for both types of farms. The majority of farms using conventional sapling (48%) operating at a low level of TP while 46% of farms using tissue culture sapling operated at a high level. On average, TP for tissue culture farms was 27.9% higher than conventional farms even though comparative analysis did not show any significant difference.

Table 4: TP level scale

TP Level	Sapling Type		Overall
	Conventional	Tissue Culture	
Low (1.00 - <2.00)	10	9	19
Moderate (2.00 - <3.00)	4	11	15
High (>=3.00)	7	17	24
Total	21	37	58
Average	2.62	3.35	3.09
Standard Deviation	1.34	2.41	2.10
Minimum	1.14	1.01	1.01
Maximum	5.79	11.41	11.41
t-value (comparative test)			1.292

Insignificant at 10% level of significance using t-test

Efficiency analysis

Cobb-Douglas production function estimation using MLE method is shown in Appendix 5. Parameter (β_i), which was the estimated production factor coefficient that had significant relations with production, was land area, labour and sapling with a 5% level of significance. Three other factors i.e. fertilizer, pesticide and depreciation did not have significant relationship with production although were still needed for operation. Assuming other factors are constant, a 1% increase in land area and sapling will increase production as much as 0.5% while a 1% increment of labour will contribute to a rise of 0.3% in production.

Estimated γ value (0.88) meant that 88% of the factors that influenced the farm's efficiency were controllable by farmers, such as the combination of inputs used. The remaining 12% that affected efficiency were uncontrollable factors including the weather, location, disease, soil condition and other factors that were not analysed in this study. The TE percentages for the farms involved in this study were in the range of 13% - 91% with an average of 72.29%. The majority of farms were in the high scale of efficiency (52%) followed by moderate scale (43%).

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Analysis results in Table 5 showed that the average TE for tissue culture farms were higher (73.66%) with the majority was in the high scale (57%) followed by the moderate scale (41%). Meanwhile, the average TE for conventional farms were lower (69.88%) with the majority being in the moderate scale (48%) followed by the high scale (43%). Although the average TE for tissue culture farms was 5.4% higher than conventional farmers, comparative analysis did not show any significant difference

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Table 5: TE level scale and technical efficiency average

Efficiency Scale	Sapling		Overall
	Conventional	Tissue Culture	
Very low (< 25%)	0	1	1
Low (25% - 50%)	2	0	2
Moderate (50% - 75%)	10	15	25
High (> 75%)	9	21	30
Total	21	37	58
Average (%)	69.88	73.66	72.29
Standard Deviation (%)	13.25	13.20	13.23
Minimum (%)	44	13	13
Maximum (%)	91	88	91
t-value (comparative test)			1.047

Insignificant at 10% level of significance using t-test

CONCLUSION AND RECOMMENDATIONS

This study proved that tissue culture banana sapling farming was more cost effective than conventional sapling farming as was shown by a lower cost of production per acre. As a result, net incomes per season for tissue culture farmers were also higher. Quality assurance with disease-and-pest-free banana sapling would produce more high quality yield.

Although overall TP was still at a moderate level, this study showed that tissue culture farms were more productive in achieving a higher TP. Despite the moderately high value of TE, this did not mean that farm's improvements were not required. TE was defined as the farms' current output production capability compared to actual potential (the best farm in the sample) with the utilization of current technology. TE indicator could be used to identify problematic farms in terms of resources and input combination. Advisory and consultancy services especially in agronomic practices were still needed by those involved in banana production. Good Agricultural Practices (GAP) must be made compulsory to commercially oriented farms to ensure quality and efficiency.

MARDI must provide *in situ* training to farmers who are newly-introduced to tissue culture saplings to ensure the agronomic management of the banana trees are practised correctly. *In situ* training by the technology generator should be conducted. Technology transfer must not be restricted only to sales at nursery and exhibitions but must also be extended to promotions and courses. In Malaysia, banana farming either using conventional or tissue culture sapling was still a labour intensive activities. Labour, land and sapling are major contributing factors towards production. Knowledge of optimising input usage will increase efficiency resulting in an increase in production.

Banana farming industry should be brought into attention because as technology increases the government's target could be realised. In NKEA, among the objectives is to produce more high quality fruit which fulfil the food safety standard. As a conclusion, the usage of tissue culture banana sapling should be adopted on a broader scale as it offers higher income. Farmers are encouraged to use tissue culture sapling to reduce their production costs. Furthermore, MARDI is recommended to increase its production of high quality tissue culture saplings for high potential crops as a catalyst to elevate the productivity of the nation's crop industry.

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