

Potential and Viability of Chilli Cultivation Using Fertigation Technology in Malaysia

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ABSTRACT: Chilli, or *Capsicum annum*, is a high value cash crop. Cultivation of chilli had been done using the conventional method and fertigation system. There are two methods of fertigation system practiced in Malaysia, which are planting chilli under rain shelters and open fertigation and planting chilli without rain shelter. All three planting systems have their own advantages and disadvantages. This study was conducted to evaluate the costs and benefits of chilli cultivation using both the fertigation system and conventional methods. Data were obtained from the pilot project plot under MARDI and the Department of Agriculture. The cost-benefit analysis showed that the costs of production for chilli using both fertigation systems were RM1.19/kg (under the rain shelter) and RM1.56/kg (open fertigation), respectively, compared to RM2.03/kg using the conventional method. The net income per season per hectare for planting chilli using the fertigation system under rain shelter was RM105,654 and open fertigation was RM77,415, which were higher than the conventional method (RM55,900). The higher net income was due to the high yield of chilli, almost twofold per hectare, than the conventional method. The partial budget analysis also showed a higher benefit value than the implication value in the event of farmers switching from using conventional methods to chilli cultivation using both fertigation systems. Overall, chilli cultivation using fertigation technology is proven to improve chilli yield and has a high viability. The high cost or initial capital will be offset by the high production yield. This technology is also more environmentally friendly than the conventional methods and in accordance with the practice of sustainable agriculture development, besides conforming to the present national agriculture agenda.

KEYWORDS: Chilli Cultivation, Fertigation Technology, Malaysia.

INTRODUCTION

Chilli or its scientific name *Capsicum spp.* is a kind of fruit vegetables from the family Solanaceae [1]. Chilli is a plant that grows upright, rooted, with branched green stems and the leaves are light green to dark green and oval width. The chilli flower has five white petals grown out of the branches and a leaf-shaped pendant. The fruit is an elongated tapered shape.

Chilli is widely used as flavoring in cooking and food [2]. It consists of various species and varieties. In Malaysia, there are two kinds of chilli, red chilli / small red chilli, known as the bird's eye pepper which is grown commercially, and the large chilli. Among the large chilli varieties, Kulai 469, Kulai 151, Kulai 223, 461 and Kulai Kulai 568 are the most preferred by growers, while the bird's eye chilli popular among entrepreneurs are Centel and Bara. In Malaysia, chillies are most commercially grown in the lowlands. There are two ways of chilli cultivation, which are using the conventional method and the fertigation systems. The fertigation system is divided into two planting techniques: planting under rain shelter and open fertigation [3].

The role of agriculture in the economic growth of developing countries is important [4, 5, 6]. The use of technology is essential in improving the yield and income of farmers. Therefore, the adoption and use of new technology is important in the growth of the agricultural sector. Planting chilli using fertigation technology is growing and the techniques have been proven to be beneficial. Planting chilli using fertigation technology is increasingly becoming the choice of entrepreneurs. Planting chilli using fertigation technology is effective in improving the growth and yield of chilli, up to 3-4 fold compared to the conventional methods. With the total area of agriculture land that is shrinking, fertigation systems can maximize the use of limited land to increase crop production capacity.

In this system, fertilization and irrigation are done simultaneously and directly to the plant root area. Fertigation system is also an alternative method to prevent soil-borne diseases as well phytium and able to increase crop yields [7]. Fertigation technology has proven to increase the yields of crops such as chilli, eggplant and rockmelon [8, 9]. Fertigation technology applications in chilli can improve crop yields and ease of management. In Malaysia, planting using the fertigation system can be carried out under a rain shelter or open fertigation [3]. Both techniques have the advantages and disadvantages in terms of agronomic and economic management. Therefore, this study was carried out to compare the economic value of planting chilli using the fertigation system (under rain shelter and open fertigation).

RESEARCH METHODOLOGY

This study focused on the comparison in term of benefits, costs, and revenues between the conventional chilli cultivation and two fertigation system methods: planting under rain shelter and open fertigation. The evaluation of chilli cultivation using fertigation technology was done to observe the viability of this technology and the potential and appropriateness of this technology to be adopted by agricultural entrepreneurs and farmers to increase their production of chilli. Secondary data collection for chilli production using the fertigation technique was done in three project areas, namely (1) Fertigation Crops Complex at MARDI Kluang, Johor, (2) MARDI Serdang, Selangor, and (3) commercial-scale pilot production project in Klang, Selangor. Data collection was done for two years, starting from 2014 until 2015. For the conventional method, the same data were obtained from the Department of Agriculture.

The analyses performed were the cost and revenue analysis, viability analysis, and partial budget analysis. The obtained data were used to prepare the cash flow and subsequently, financial analysis was done to compare these two cultivation systems. Cost and revenue analysis was conducted to compare the revenues and costs of production per hectare of chilli production using the fertigation system and conventional method. The purpose of this cost and revenue analysis was to identify the variable costs and fixed costs involved in chilli cultivation for both methods, as well as estimating the incomes earned by chilli growers based on the secondary data obtained from the MARDI Plot and Department of Agriculture.

The parameters involved were gross and net incomes, gross and net margins, production costs per kilogram, and profit margins per kilogram. The variable cost was the value and quantity of inputs that changed according to the scale of production. Variable costs for both cultivation systems were fertilisers, labours, insecticides, pesticides, and herbicides, while the fixed costs or capital costs included the construction of infrastructures such as the irrigation systems, farm machineries, farm roads, and farm stores. Viability analysis was a tool used to assess the viability of the project for a certain period. Normally, viability analysis was used to estimate the feasibility and the time needed by an enterprise to prop up the total amount of investments in the specified period of time. Viability analysis of a project was made by constructing cash flow charts within 10-15 years. In this study, cash flow charts for the last 15 years were prepared. In the cash flow charts, financial analyses such as net present value (NPV), internal rate of return (IRR), capital return period, and sensitivity test were performed.

Partial budget analysis method or tool was applied to assess the right choice when there were two options at a time. In this study, there were two alternative options for growers of chili planting, which were by using the fertigation systems and the conventional cultivation methods. The cost and revenue data were used to analyze the differences between the cost and the revenue value for both alternatives [10]. In the partial budget analysis, the comparison between the benefits and implications in the application of the fertigation system and the conventional method were applied. Two major factors were assessed which were additional revenue and costs as well as reduction in cost and revenue. For example, in this study, if the implications of the fertigation technology were higher than the value of the benefits, this method would not be recommended to entrepreneurs and vice versa.

RESULTS AND DISCUSSION

COST OF PRODUCTION

The cost of production of the project was divided into two, fixed or capital cost and variable cost. Fixed cost was the cost of development that was used as the capital to develop the farm. Among the fixed costs involved in the development of farm were the infrastructures for irrigation systems, roads, stores, farm machineries, and rain protective structure for chilli cultivation using the fertigation system in lowland areas. On the other hand, the variable costs involved expenses that varied according to the scale of production such as the cost of labours, planting materials, fertilisers, pesticides and utilities.

Two major infrastructures were required in chilli cultivation using the fertigation system, which were the fertigation irrigation system and rain shelter. Meanwhile, in open fertigation, the irrigation system was the major infrastucture. The development cost of planting chilli using the fertigation system under rain shelter per hectare was RM270,000 of the overall costs, compared to the development cost of open fertigation, which was RM50,000 (Table 1). The development cost for planting chilli under rain shelter was five times higher than the open fertigation for one-hectare area. Input, labor and other costs were almost the same for both fertigation cultivation systems. Chilli cultivation using the fertigation system that can be automated was able to reduce the reliance on manual labours, compared to the conventional cultivation method.

Table 1: Comparison of the costs of production of chilli cultivation using fertigation system under rain shelter and open fertigation

Parameter	Average cost for planting chilli using fertigation system under rain shelter		Average cost for planting chilli using open fertigation		Planting chilli using conventional method	
	(RM / ha / year)	%	(RM / ha / year)	%	(RM / ha / year)	%
Development cost	270,000	78.7	50,000	40.27	80,000	38.7
Input cost	44,292	12.92	48,570	39.12	30,000	23.2
Labour cost	21,600	6.34	21,600	17.4	43,200	33.5
Other costs	7,000	2.04	4,000	3.21	6,000	4.6
Total	342,892	100	124,170	100	129,200	100

YIELD AND INCOME

Table 2 shows a comparison of chilli yield per hectare between the fertigation system and the conventional method for one season of chilli crops. For one hectare of land, the plant density for chilli cultivation using the fertigation system under rain shelter was 7,720 plants, compared to 9,000 plants in open fertigation. The average yield for chilli cultivation was 27,720 kg and 22,500 kg for under rain shelter and open fertigation system respectively. The plant density under rain shelter was limited, but the plant under the structure gave a higher yield compared to open fertigation. The average yield per plant under rain shelter was 3.5 kg, compared to 2.5 kg for chilli cultivated using the open fertigation system. Planting chilli under rain shelter could reduce the risk of pest and disease, mainly in the rainy season. The production cost for planting chilli using the fertigation system under rain shelter was RM 32,946 and RM 35,089 for open fertigation. The average farm price for chilli was RM 5.00 per kilogram. Entrepreneurs that used the fertigation system were able to earn an average net income of RM 105,654 for chilli planting under rain shelter and RM 77,415 for open fertigation for one season of cropping.

Table 2: Comparison of chilli yield per hectare between planting using fertigation under rain shelter and open fertigation for one season of chilli crop

Parameter	Planting chilli using fertigation system under rain shelter	Planting chilli using open fertigation	Planting chilli using conventional method
Average yield (kg/ha)	27,720	22,500	18,000
Average gross income (RM) @ RM5.00/ kg	138,600	112,500	90,000
Production cost (RM/kg)	1.19	1.56	2.03
Average production cost (RM/ha)	32,946	35,085	36,600
Average net income (RM/ha)	105,654	77,415	55,400

VIABILITY ANALYSIS

A viability analysis was performed to assess the usability of both technologies based on the financial flows (Table 3). Despite the high development cost, chilli cultivation using the fertigation system had a short-term capital return, which was three years. If the benefit-cost ratio was compared, entrepreneurs who used the fertigation system under rain shelter were able to earn RM 0.92 for each RM 1.00 invested in the production of chilli and RM 0.86 for open fertigation. Meanwhile, planting chilli using the conventional method was able to get RM 0.59 for each RM 1.00 invested. Planting chilli using the fertigation system was more profitable compared to the conventional method. Results of the viability analysis showed that the use of fertigation technology in chilli production was more viable in the long run. Comparison of the viability indicators for all chilli production systems showed higher values of indicators for chilli cultivation using the open fertigation system.

Table 3: Viability analysis of chilli production using the fertigation system and conventional method

Viability indicators	Planting chilli using fertigation system under rain shelter	Planting chilli using open fertigation	Planting chilli using conventional method
Net present value (NPV) @ 10%	435,400.12	686,230.31	406,649.71
Internal rate of return (IRR)	48.02%	49.7%	47.5%
Capital return period (year)	3	1	2
Benefit-cost ratio (BCR) @ 10%	1.92	1.86	1.59

PARTIAL BUDGET ANALYSIS

Partial budget analysis showed that the benefit value earned was higher than the amount of the implications for chilli cultivation using the fertigation system under rain shelter (+RM 28,800) and open fertigation (+RM 196,600) (Table 4). Therefore, it was recommended to shift the conventional method of chilli planting to the fertigation technology, either under rain shelter or open fertigation system. Partial budget analysis also revealed that planting chilli using open fertigation gave more benefits.

Table 4: Partial budget of chilli cultivation using fertigation technology compared to the conventional method

Changes from conventional method to fertigation system					
	Method of chilli production			Method of chilli production	
	Fertigation cultivation under rain shelter	Open fertigation		Fertigation cultivation under rain shelter	Open fertigation
Benefits			Implications		
<i>Yield increase</i>	27.72 tonnes * 2 season/year * RM5.00/kg * 1000 = RM 277,200	22.5 tonnes * 2 season/year * RM5.00/kg * 1000 = RM = RM 225,000	<i>Cost increase</i>	Rain shelter structure (SPH) = RM 270,000	Irrigation system = RM 50,000
<i>Cost reduction</i>	Average labour cost / year = RM 21,600	Average labour cost / year = RM 21,600			
Total benefits	RM 298,800	RM 246,600	Total implications	RM 270,000	RM 50,000
	+ RM 28,800	+ RM 196,600			

DESCRIPTION OF TECHNOLOGY

Fertigation technology is a cultivation system without the use of soil. The original purpose of this method was used to prevent soil-borne diseases that often attack the roots of plants [11, 3]. In the fertigation system, the crops media such as coco peat, perlite, and burnt paddy husk are used as a replacement for soil. The crops media are filled into polybags according to the appropriate sizes. Besides that, in this fertigation system, irrigation and fertilisation are done simultaneously and directly to the crops' roots [12]. This fertigation system is able to increase crop yields and reduce the use of fertiliser by supplying a fertiliser solution based on each crop's formulation, while distributing the solution to the crops based on their growth levels and needs. Fertigation technology is able to save the cost of production, as it does not involve the cost of land preparation, weeding, and fertiliser spreading, unlike the conventional method. The technology can be automated using a timer; therefore, it can reduce the labour force.

In Malaysia, planting using the fertigation technology was carried out in two ways: planting chilli using the fertigation system under rain shelter and open fertigation without using rain shelter. The irrigation system for both methods was the same. Planting using open fertigation is more favored by entrepreneurs because of the low initial cost compared to chilli cultivation under rain shelter. However, planting chilli using the fertigation system under rain shelter can minimize the use of pesticides to control pests and diseases. The main advantage of cultivation chilli under rain shelter is the ability to plant continuously without the interruptions of weather such as the rainy season.

Chilli cultivation using the fertigation technology can be used for the production of red chilli and bird's eye chilli. Planting chilli using fertigation technology not only can be done in the same area repeatedly, but also can give the yield 2 to 3 fold compared to the conventional cultivation methods. The high production yield could offset the high initial development cost. The average yield of planting red chilli using the fertigation system is up to 3.5 kg per polybag, which takes 6 months, while the production for the conventional method is 1.5 kg with the same cultivating period of 6 months [3]. Cultivation under rain shelter can give higher yields than in the open field planting [13]. However, high yield depends not only on extensive cultivation area but also the potential gains that may result either from the use of better planting materials or crop management practices [14]. This technology creates a high interest among farmers and entrepreneurs, although the initial investment is higher when compared to the conventional methods. The high development and initial costs can be offset by the high crop yield. No technology, without taking into account the ecological and economic stability, will affect the productivity and income, unless it is adopted by the majority of farmers [15]. Furthermore, the use of technical innovations by farmers also requires accurate and detailed information about the costs and returns [16]. Innovation and new technologies are an important factor in increasing agricultural output and competitiveness in the long term [17].

The increased in yield in the fertigation cultivation techniques could reduce dependence on the imports of chilli. It could also simultaneously reduce the country's imports of chilli and create opportunities for entrepreneurs to explore chilli-based processing products, such as chili paste, sauce, puree and other products [18, 19]. The use of fertigation technology can ensure a continuous production of chilli for downstream processing products.

CONCLUSION

In short, chilli cultivation using the fertigation method had been proven to increase the yield and income of farmers and entrepreneurs compared to the conventional method. The high cost or initial capital will be offset by the higher production. A significant increase in yield of up to two or three fold more than the conventional method is able to provide a high net income for entrepreneurs. However, the high investment for the construction of rain shelter and irrigation system has impeded the use of this technology among farmers. Nevertheless, the viability analysis showed that this technology has a strong competitive edge and is suitable to be adopted by farmers as it can provide higher returns than the conventional method. If it is viewed from the environmental sustainability perspective, this technology is more environmentally friendly than the conventional method and it is in accordance with the agenda of the current agricultural practices, namely sustainable agricultural development practices.

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