International Conference on Agricultural and Food Engineering for Life (Cafei2012)
26-28 November 2012

CAFEi2012-141

AN INNOVATIVE FARMING METHOD ENSURING HIGH PRODUCTION OF PLANTING MATERIALS IN PEPPER (*PIPER NIGRUM* L.) PLANTATION

Chen, Y.S.[1] and Kho, P.E.[1]

[1]Malaysian Pepper Board, Lot 1115, Jalan Utama, Pending Industrial Area,
P. O. Box 1653, 93916, Kuching Sarawak, Malaysia
Email: yschen@mpb.gov.my, khope@mpb.gov.my

ABSTRACT

Shortages of planting materials remain the major challenge of pepper industry nowadays. Therefore, a new farming method, namely W-configuration cultivation method has been developed to overcome the constraint of planting materials shortage in pepper industry. This farming method can ensure high production of pepper cutting and at the same time to maximize land use in pepper farm. An experimental plot was established at Rapak, Sri Aman, Sarawak, for the assessment on cutting production for the first two years and yield performance for the subsequence years. W-configuration cultivation method is varied from the traditional cultivation method mainly in the way of post positioning. In W-configuration cultivation method, three wooden posts of 2 meter height were positioned in W-configuration, with one intermediate post set up-righted and the other two lateral posts positioned 45° from the ground. The essence of this method is the use of only one pepper cutting for the three posts or per vine. For the up-righted intermediate post, the pepper shoot was trained similar to the traditional planting, by the use of three terminal shoots. Whilst, stolon or locally known as water shoot which emerged from the main vine was buried on the ground with top soil particularly on the nodal part prior to be trained on the two lateral posts. This treatment would promote growth of adventitious root and eventually shoot growth. The growth performance of water shoots trained on the lateral post was found to be similar to the terminal shoots from the intermediate post in term of growth morphology and growth rate. Based on the preliminary data obtained, the cuttings production through W-configuration cultivation method is approximately triple compare to the traditional planting method. This paper will enlighten the thorough planting procedure of W-configuration cultivation method and ROI analysis on recommended pepper plantation mainly for pepper cutting production.

Keywords: *pepper, W-configuration, pepper cuttings, water shoot*

INTRODUCTION

Pepper or *Piper nigrum* L. is a perennial woody vine in the family Piperaceae that is primarily cultivated for its fruit which widely used as spice in culinary preparation, food flavouring, seasoning, perfumery and as a condiment throughout the world [1,2,3]. It has gained a global recognition as the "King of spice" due to its monetary value and trade in the international spice market [4]. Black pepper is an important cash crop with potential for export in Malaysia particularly in Sarawak whereby more than 98% of pepper was produced from the state of Sarawak. According to the International Pepper Community (IPC) 2011, Malaysia has the distinction of being the world's fifth largest pepper producer country with an output of 25,600 tonnes and total export of 14,201 tonnes which worth RM285.27 million in year 2011. In addition on this, domestic consumption of pepper shot up by 11% to 7,828 tonnes compared to 7,069 tonnes in year 2010. Pepper planting was a lucrative endeavour and the demand on food and non-food pepper based products is expected to increase in future. Consequently, a constant supply of planting materials is essential for sustaining and boosting up the pepper productivity of the nation.

A pepper plant has two types of branches. One is the straight, upward growing, orthotropic, monopodial with adventitious roots at each node clinging on the support. This type of branch is referred to as the 'orthotropic branch'. It is also called the "orthotropic stem', 'orthotropic shoot', 'terminal shoot' or simply 'the terminal'. Whilst, the other is the lateral growing, plagiotropic, sympodial branch which bear flower and fruit spikes at the node. This type of branch is known as the 'plagiotropic branch', 'lateral branch' or 'the lateral'.

Pepper cuttings used for planting is sourced from the orthotropic branch (terminal shoot) of a healthy and vigorously growing young vine with varying number of nodes. Traditionally in Sarawak, a five- to seven-node cutting is used for planting. Currently, the five-node cutting is recommended. First round of pruning is normally carried out at six months after planting and subsequent pruning at four-month intervals. Under the traditional practice, a vine normally produces about seven to ten (7-10) five-node cuttings in its first year after planting and another sixteen to twenty-two (16-22) five-node cuttings in its second year [5].

The Malaysian Government targets at increasing the pepper cultivated area from the current 14,174 hectares to 15,150 hectares by year 2015 and to 15,800 hectares by year 2020. This means there will be an increase of 976 hectares of pepper cultivated area in the next five years. Based on a planting density of 2,000 vines per hectare, there will be a need for 390,400 cuttings per year in order to achieve this target. However, low productivity and occurrence of pests and diseases have restricted pepper cultivation through conventional method. Therefore, this innovative farming method is undoubtedly a novel yet creative way to produce adequate planting material for large-scale pepper cultivation. Besides, the production of pepper cuttings through this new farming approach would create potential new income for 67,247 of pepper smallholders in Malaysia, who traditionally cultivate pepper for its peppercorn production.

MATERIALS AND METHODS

Materials

Pepper cuttings used for planting is taken from the orthotropic branch (terminal shoot) with varying number of nodes. Traditionally in Sarawak, a five-node cutting is recommended. However, at time of planting material shortage, two-node and even one-node cutting can also be used. The field establishment of such shorter cuttings is slower initially and it is necessary that such cuttings are rooted and grown in polybags for three to four months before transplanting to the field. In this study, only five-node cutting were counted since it is the most ideal planting materials.

Establishment of experimental plot

An average of 0.32 acres planting area which is located at Rapak, Sri Aman has been identified as the experimental plot for this invention. The plot was planted with approximately 315 vines of recommended pepper variety i.e. cv. Semongok Aman.

In this project, the assessment only focuses on pepper cuttings production. The single pepper vine was trained in a way that three wooden posts of 2 meter height were positioned in W-configuration, with one intermediate post set up-righted and the other two lateral posts positioned 45° from the ground. The yield of cuttings production for W-configuration cultivation method was calculated from cuttings obtained from all the three post per vine while the control only taking into account the intermediate up-righted post which comparable to the traditional planting. The assessment was carried out quarterly for up to two years.

ROI analysis

The analysis takes into account pepper cuttings production per cycle (2 years) in 1 hectare of planting area, with a planting density of 2,000 vines per hectare. The parameters of investment cost mainly are made up of non-factor cost which consists of pepper posts (belian), pepper cuttings, fertilisers, dolomite, weedicide, pesticide and miscellaneous farm implements, whilst, labour cost is considered as factor cost. The gross revenue is solely depending on the cuttings production. All of the statistical data were sourced from Division of Production & Entrepreneurs Farmers Development, Malaysian Pepper Board. The standard market price for fresh cutting or un-rooted cutting is currently RM 3.00/cutting and the return on investment is calculated as in formula (1).

$$\text{Return on Investment (ROI)} = \frac{\text{(Gain from Investment} - \text{Cost of Investment)}}{\text{Cost of Investment}} \quad (1)$$

RESULTS AND DISCUSSIONS

Plant support and farm structural design

For pepper vine support, Belian (*Eusideroxylon zwageri*) post is recommended by considering the durability and selectivity of pepper root. In W-configuration cultivation method, the suggested size of Belian post is preferably not less than 3 inch in diameter and not less than 5 inch in height. W-configuration cultivation method consists of three wooden posts of 2 meter height were positioned in W-configuration, with one intermediate post set up-righted and the other two lateral posts positioned 45° from the ground as shown in Fig. 1. Farming structural design is similar to the traditional planting method. Both of the distance between row and between vines is recommended at least 2 meter (Fig. 1C and D).

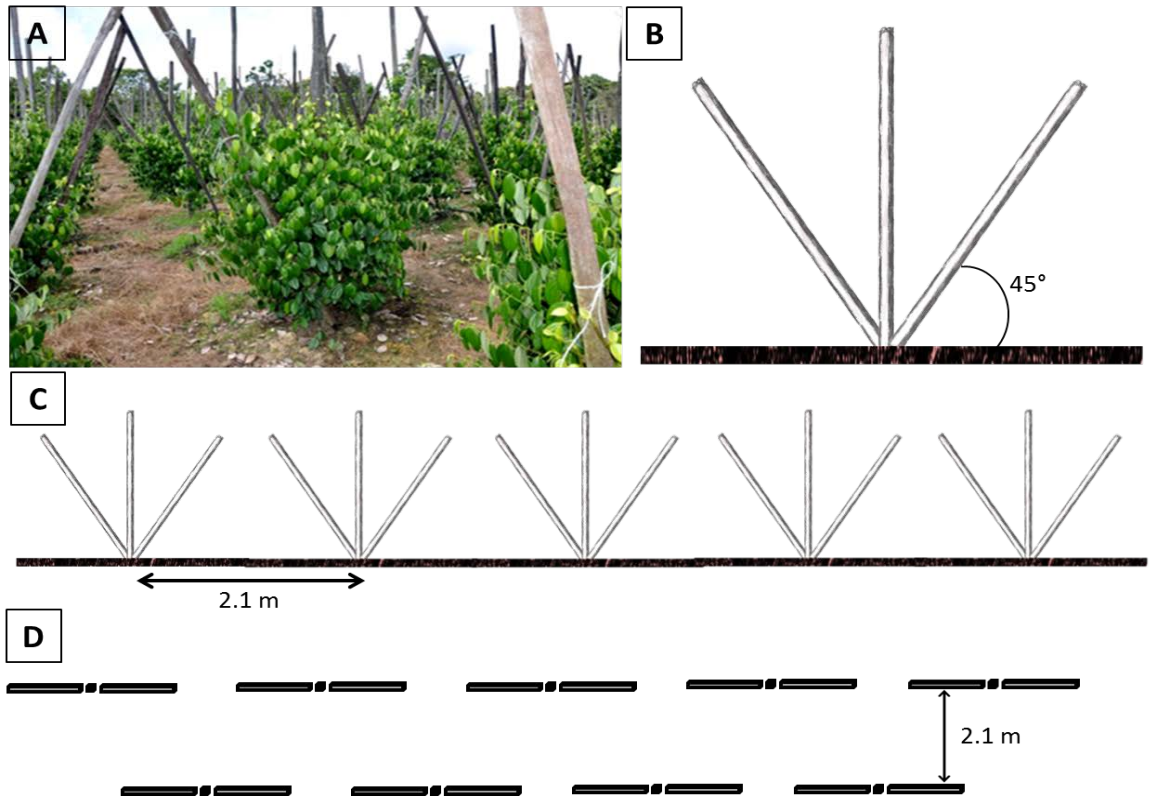

Fig. 1: Structural design of pepper vine support by Belian post. **A.** Experimental plot. **B.** Post arrangement for W-configuration cultivation method **C.** Horizontal view of pepper vine in single row. **D.** Arial view of two row of pepper vines.

Good agricultural practise (GAP)

Traditional cultivation practise in Malaysia is to train a five-node cutting onto a post with the three lower nodes are buried in the soil at an angle of 20º to 35° while the fourth node is level with the ground surface. The fifth node is above ground and placed close to the support. The first pruning is normally carried out six months after field planting and the terminal shoot is pruned back to about 0.5 m from the mound. Three new terminal shoots which originating from the axillary buds are allowed to develop [5, 6].

Unlike the traditional cultivation method, W-configuration cultivation method utilized three wooden posts of 2 meter height were positioned in W-configuration, with one intermediate post set up-righted and the other two lateral posts positioned 45° from the ground. The essence of this method is the use of only one pepper cutting for the three posts or per vine. For the up-righted intermediate post, the pepper shoot was trained similar to the traditional planting, by the use of three terminal shoots. Whilst, stolon or locally known as water shoot which emerged from the main vine was trained on the two lateral posts. Before this, stolon (water shoot,

hanging shoot or runner shoot) has never been recommended as planting material in Malaysia due to unpromising growth and it normally retarded before maturity. Therefore, stolon that is hanging or trailing on the ground is normally removed once emerged to reduce fertilizer uptake [6]. However, there is a breakthrough in this project. The stolon was found able to achieve excellence growth performance which is comparable to the terminal shoot with condition the stolon must emerged from the basal of vigorous growing vine and the nodal part is still viable. The stolon which emerged from the main vine was buried on the ground with top soil particularly on the nodal part prior to be trained on the two lateral posts (Fig. 2). This treatment would promote growth of adventitious root and eventually shoot growth. In line with the current finding, stolon is extensively used in India for clonal propagation [7].

Fig. 2**: a.** Runner shoots on the soil. **b.** Closer view of runner shoot buried with top soil at nodal part. **c.** Runner was tied and trained on Belian post.

ROI analysis

Implementation of W-configuration cultivation method for the production of pepper cutting at stock nursery or plantation is novel in all pepper producing countries. A ROI analysis has been carried out to assess the viability of investment into this type of farming approach. The cost estimation of one hectare pepper plantation establishment is showed in Table 2.

Based on ROI calculation as in (2), the pepper cutting production plantation via implementation of W-configuration cultivation method able to achieve index of 1.30 in return on investment, which is equivalent to 130 per cent of return within two years or per cycle. The ROI revealed that the newly developed farming method is very viable for investment. In addition, the return would be much more lucrative for the subsequence cycles as the cost of Belian support that has attributed to the greatest amount of investment cost for pepper plantation is reusable. Mathematically, for the subsequence cycles of planting which excluded the cost of Belian support, the return can increased dramatically up to 820 per cent.

Comparing with the traditional planting methods, the maximum cuttings obtainable is approximately 6,4000 cuttings whilst the newly developed planting method can produce up to 150,000 cuttings which is estimated triple higher, within two years. In other word, newly developed W-configuration cultivation method can produce additional of 86,000 cuttings that could make up to a total profit of RM 258,000 provided all of the cuttings are sold at the price of RM 3 per fresh cutting.

For the first two years of traditional practice of pepper cultivation, the ROI remains negative even with the assumption whereby all of the 36,000 cuttings produced have been sold out as indicated in (3). The ROI will

be able to achieve index of 0.50 only at year three as shown in (4). The estimated ROI index is 0.50 which means the grower can only get fifty per cent of return out of the investment cost at year three. This is still less lucrative compare to the viability of new farming method.

ROI for W-configuration cultivation method per cycle (2 years):

$$\textbf{ROI} = \frac{\textbf{(Gain from Investment } \square \textbf{ Cost of Investment)}}{\textbf{Cost of Investment}} = \frac{\textbf{RM (450,000-195,681)}}{\textbf{RM 195,681}} = \textbf{1.30} \quad \textbf{(2)}$$

**Based on survey done by Sim et. al in 2011, conservative estimation of cutting yield per vine with three posts is 21 cuttings (first year) and 54 (second year). Thus, for first year, 2,000 vines x 21 cuttings = 42,000 cuttings; for second year, 2,000 vines x 54 cuttings = 108,000 cuttings.*

ROI for traditional cultivation method up to two years:

$$\textbf{ROI} = \frac{\textbf{(Gain from Investment } \square \textbf{ Cost of Investment)}}{\textbf{Cost of Investment}} = \frac{\textbf{RM (150,000-153,222)}}{\textbf{RM 153,222}} = \textbf{-0.02} \quad \textbf{(3)}$$

**Based on survey done by Sim et. al in 2011, conservative estimation of gain from pepper cutting = (14,000+ 36,000) x RM 3 = RM 150,000. For the first year, 2,000 vines x 7 cuttings = 14,000 cuttings; for second year, 2,000 vines x 18 cuttings = 36,000 cuttings.*

ROI for traditional cultivation method up to three years:

$$\textbf{ROI} = \frac{\textbf{(Gain from Investment } \square \textbf{ Cost of Investment)}}{\textbf{Cost of Investment}} = \frac{\textbf{RM (230,496-153,222)}}{\textbf{RM 153,222}} = \textbf{0.50} \quad \textbf{(4)}$$

**Gain from peppercorn production in year 3= RM 80,496. Total gain within 3 year = cuttings gain+ peppercorn gain= RM 150,000 + RM 80,496 = RM 230,496*

e-ISBN 978-967-960-322-4

Table 2**:** Cost estimation for establishment and maintenance of pepper farm mainly for the production of pepper cutting per cycle (one hectare = 2000 vines)

Items	Unit	Unit Cost	Annual Expenditure Yr.1	Yr.2
NON-FACTOR COSTS				
(a) Pepper Posts(belian)	RM/post	25.00	150,000	
(b) Pepper cutting	RM/post	3.00	7,200	
(b) Fertilisers(0.5kg/pt, Yr1)	RM/kg	2.56	2,560	5120
(c) Dolomite(1kg/pt, Yr1)	RM$/kg	0.50	1,000	500
(d) Weedicide	RM/ltr	43.68	2,184	1,310
(e) Pesticide	RM/ltr	45.55	456	911
(f) Misc. Farm Implements			600	120
SUB-TOTAL (NON-FACTOR COST)			16,4000	7,961
LABOUR COSTS	WKD	RM/WKD		
(a) Felling & Burning		40.00	2,400	
(b) Ploughing & Harrowing		40.00	4,400	
(c) Lining & Mounding		40.00	2,800	
(d) Erecting Posts & Planting		40.00	1,600	
(e) Fern Gathering & Shedding		40.00	600	
(f) Fertilising		40.00		2,400
(g) Liming		40.00		800
(h) Spraying Chemicals		40.00	800	1,200
(i) Weeding		40.00	1,200	720
(k) Cuttings Harvesting		40.00		
(l) Mounding		40.00	2,400	2,400
SUB-TOTAL (LABOUR COST)			16,200	7,520
TOTAL ANNUAL PRODUCTION COST = NON-FACTOR COST + LABOUR COST			180,200	15,481
PRODUCTION & REVENUE				
1. Yield per hectare	Cuttings		42,000*	108,000*
2. Gross Revenue	RM/cutting	3.00	126,000	324,000
3. Gross Margin / hectare	RM/ha		-54,200	308,519
4. Gross Margin / work-day (Annual labour requirement for mature garden is 725 wkd/yr/ha)	RM/wkd		-77.75	425.54

$$\textbf{ROI} = \frac{\textbf{(Gain from Investment } \square \textbf{ Cost of Investment)}}{\textbf{Cost of Investment}} = \frac{\textbf{RM (450,000-195,681)}}{\textbf{RM 195,681}} = \textbf{1.30}$$

**Source: Annual report of Division of Production & Entrepreneurs Farmers Development, Malaysian Pepper Board.*

e-ISBN 978-967-960-322-4

Table 3**:** Cost estimation for establishment and maintenance of pepper farm mainly for the production of pepper cutting per cycle (one hectare=2000 vines)

Items	Unit	Unit Cost	Annual Expenditure Yr.1	Yr.2	Yr.3
NON-FACTOR COSTS					
(a) Pepper Posts(belian)	RM/post	25.00	50,000		
(b) Pepper Cuttings	RM/cutting	3.00	7,200		
(c) Fertilisers(0.5kg/pt, Yr1)	RM/kg	2.56	2,560	5,120	7,680
(d) Dolomite(1kg/pt, Yr1)	RM$/kg	0.50	1,000	500	500
(e) Weedicide	RM/ltr	43.68	2,184	1,310	1,310
(f) Pesticide	RM/ltr	45.55	456	911	911
(g) Misc. Farm Implements			600	120	120
SUB-TOTAL (non-factor costs)			64,000	7,961	10,521
LABOUR COSTS	WKD	RM/WKD			
(a) Felling & Burning		40.00	2,400		
(b) Ploughing & Harrowing		40.00	4,400		
(c) Lining & Mounding		40.00	2,800		
(d) Erecting Posts & Planting		40.00	1,600		
(e) Fern Gathering & Shedding		40.00	600		
(f) Fertilising		40.00		2,400	2,400
(g) Liming		40.00		800	800
(h) Spraying Chemicals		40.00	800	1,200	1,200
(i) Weeding		40.00	1,200	720	720
(j) Pruning/Tying Apical Buds		40.00	2,000	4,000	1,500
(k) Flowering Picking		40.00	3,000	9,000	
(l) Harvesting & Processing		40.00			20,000
(m) Remounding		40.00	2,400	2,400	2,400
SUB-TOTAL (labour costs)			21,200	20,520	29,020
TOTAL ANNUAL PRODUCTION COST			85,200	28,481	39,541
Amortized Annual Value Of Establishment Cost					10,282
Total Annual Production Cost (MATURE GARDEN)					49,823
Total Annual Production Cost (EXCLUDING LABOUR COSTS)					20,803
PRODUCTION & REVENUE					
1. Yield per hectare	KG	(Black Pepper)			4,800
2. Gross Revenue	RM/kg	16.77			80,496
3. Gross Margin / hectare	RM/ha				69,975
4. Gross Margin / work-day	RM/wkd				96.52
(Annual labour requirement for mature garden is 725 wkd/yr/ha)					

NOTE : (1)*Average Yield Per Vine In Term Of :-

a). Black Pepper Equivalent = 2.4 kg. per vine

b). White Pepper Equivalent = 1.7 kg. per vine

e-ISBN 978-967-960-322-4

CONCLUSIONS

The invention of W-configuration cultivation method is anticipating in overcoming the planting materials shortage problem in our country, at the same time to assess the viability of establishing pepper farm which is mainly for cuttings production purpose. The ROI analysis proven the feasibility of this newly developed cultivation method to create potential new income for pepper smallholders in Malaysia. It was estimated to gain 130 per cent out of investment cost at the second year of planting and dramatically rise up to 820 per cent of return rates at second cycle. This is undoubtedly a breakthrough in pepper industry. In addition, source of planting material is no more a constraints in pepper farm expansion.

W-configuration cultivation method is not limiting for mass production of planting materials but also aiming at the possibility of increasing yield per hectare in long run. However, the trial is on-going and a conclusive result on yield performance will be revealed at year 2014. In comparison to the traditional planting method, ROI analysis proved that this farming approach ensuring more lucrative return, with additional profits from the selling of pepper cuttings.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Liew Tet Chin for granting permission to conduct the experimental plot in the pepper farm under his tenure. Appreciation also goes to Mr. Wan Ambi and Mr. Sang Jam, research assistant of Malaysian Pepper Board for their technical assistance in the field.

REFERENCES

[1] Philip, V.J., Dominic, J., Triggs, G.S. and Dickinson, N.M. (1992). Micropropagation of black pepper (*Piper nigrum* L.) through shoot tip cultures. *Plant Cell Report*. **12**: 41-44.
[2] Bhat, S.R., Chandel, K.P.S. and Malik, S.K. (1995). Plant regeneration from various explants of cultivated *Piper* species. *Plant Cell Report*. **14**: 98- 402.
[3] Joseph, B., Joseph, D. and Philip, V.J. (1996). Plant regeneration from somatic embryos in black pepper. *Plant Cell, Tissue and Organ Culture*. **47**:87–90.
[4] Srinivasan, K. (2007). Black pepper and its pungent principle-piperine: A review of diverse physiological effects. *Critical Reviews in Food Science and Nutrition*. **47**: 735-748.
[5] Sim, S.L., Paulus, A.D. and Eng, L. (2011). Manual for production of quality planting material of pepper. Malaysian Pepper Board.
[6] Paulus A.D., Megir G. and Eng, L. (2006). Pepper Technology Package. Booklet produced by Department of Agriculture, Sarawak, 31 pp.
[7] George, C.K., Abdullah, A. and Chapman, K. (2005). Pepper production guide for Asia and the Pacific. Joint effort of the International Pepper Community (IPC) and Food and Agricultural Organization of United Nations (FAO). IPC. Bangkok (Thailand).