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Total productivity and technical efficiency of watermelon at farm level

(Produktiviti total dan kecekapan teknikal tanaman tembikai di peringkat ladang)

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Key words: total productivity, technical efficiency, watermelon, farms

Abstract

A primary survey involving 49 watermelon farmers operating in two seasons in 2004/2005 was conducted with the objectives of assessing the farm productivity and efficiency. Data analysis indicated that the individual farm total productivity (TP) values ranged from 0.66 to 4.91. The mean TP for the individual sample farms was 2.05. The TP for the watermelon sub-sector in 2004/2005 was 1.78. The average contribution of labour to income was relatively higher than the average contribution of capital. Ordinary least square procedure (OLS) undertaken revealed that younger and higher income farmers tend to be more productive respectively than the older and lower income farmers. The Kopp and Timmer technical efficiency (TE) computed indicated that the sample farms had a mean efficiency level of 46% with standard deviation of 0.18. The productivity and efficiency of the watermelon sub-sector could be improved by increasing yield and revenue through the adoption of new technology, new variety and good seeds and reducing production costs. It is strongly recommended that irrigation system be installed in the watermelon farms to reduce the labour cost of watering and to ensure good harvests.

Introduction

Watermelon is a very popular short-term non-seasonal fruit and has been classified under major fruits by the Ministry of Agriculture and Agro-Based Industry (MOA). These major fruits are being promoted for commercial planting due to their potential in generating income to the farmers and the economy.

The total acreage of watermelon in Peninsular Malaysia has been stabilized at around 5,000 ha since 1990's, except in the year 1991 to 1993, whereby the total acreage was found to be higher (7,000–8,000 ha). This may be due to the larger acreage of farms being transplanted with oil palm at that time, and watermelon is known to be a popular cash crop during early establishment of the oil palm trees.

In the year 2002, the estimated watermelon production was about 70,000 tonnes. Despite its relatively small area as compared to the other major fruits, watermelon is known to be a significant contributor to export earning of the country. Malaysia's export of watermelon accounted for about 2% of the world's exports. Singapore is the major importer, accounting for 70% (RM29.3 million) of the total export value in 2003 (RM42 million). The other major importers are Hong Kong, Indonesia, Brunei and Taiwan.

The local demand for watermelon (including other melons) in 2002 was estimated at 127,000 tonnes valued at RM170 mil. (Anon. 2006). The inadequate local supply was supplemented by imports (mainly other

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melons) from Australia, China, Japan and Thailand.

The establishment of World Trade Organization (WTO) and the rapid liberalisation of agriculture trade have opened the agricultural sector to increasing competition and new market opportunities. Malaysia is a net exporter of watermelon. The question currently arises as whether Malaysia can improve or maintain its competitiveness in the 'glocal' markets. Unless farmers are willing to increase productivity and improve efficiency in their operations, Malaysia may lose its market shares to other competitors. More so for the watermelon sub-sector which is totally dependent on imported seeds.

The previous study on the total productivity (TP) of the agriculture food sector focused on a few commodities, which included vegetables, paddy, watermelon and broiler chickens. The TP of the watermelon sub-sector in the year 2000 was found to be 1.36 (Anon. 2002).

A study on the efficiency of selected fish-based food product sectors in 1996 and 1998 indicated that this sub-sector was dominated by the Small and Medium Industries(SMI) (Raziah 2003). The average efficiency of the firms has decreased in 1998 (0.1380) as compared to that in 1996 (0.3447). Raw materials were found to be the most important factor affecting production, followed by labour and capital.

Another efficiency study on selected fruit farms in Malaysia (Abu Kasim and Md. Yunus 1994) found that the mean technical efficiencies for starfruit, papaya, and guava farms were 0.51, 0.60 and 0.44 respectively. This study found that starfruit and guava farms were more labour intensive as compared to papaya farms. The operation that utilised the most labour was crop maintenance, especially fruit wrapping, which accounted for almost half of the labour input for starfruit and guava farms.

The total productivity of the agriculture sector in 1991–1994 was estimated at 1.98 (Mad Nasir et al. 1998), which was considered as favourable for an active investment. However, in this case the contribution was mainly from oil palm.

Watermelon was chosen for this study, due to the threat of increasing competition from cheaper producing countries, such as China and Thailand especially when the AFTA/WTO becomes fully materialised in the near future.

In this paper, the TP and technical efficiency (TE) of the watermelon farms are discussed, the factors affecting the productivity and efficiency of the farms are highlighted, and finally policy measures to improve the productivity and efficiency of the sub-sector are recommended.

Materials and methods

Source of data

Primary surveys by the enumerators and farm record keeping by the respondents were adopted to gather data in the study. Each of the respondents was given a book for him/her to record the daily activities involved in the production processes. Subsequently, the enumerators transferred the data from the record books to the structured questionnaires. The data was for the 2004/2005 operation year.

Stratified sampling design was adopted to identify the districts covered in the survey. The major districts producing watermelon were selected based on the latest statistics published by the Department of Agriculture Malaysia (DOA). The respondents were then selected at random with the cooperation of the extension agents.

The data collected were base line data on farmers, farms background, outputs, prices of outputs, inputs consumed and prices of inputs.

Theoretical framework

Productivity measurement Production activities can be defined as processes of transforming various inputs into products. Productivity is the ratio of output to input. Single factor productivity also known as partial productivity (PP) is output divided by a single factor. For example, labour productivity is the ratio of output to labour and capital productivity is the ratio of output to capital.

In a production process, many factors of production or inputs are used simultaneously. Changes in the quality and quantity of other inputs affect the productivity measure in a single input. For example, in manufacturing processes, both labour and machineries are used together. In case of a firm having sophisticated machineries, the number of employees still remained the same, thereby increasing the per capita output. Thus, we would observe an increase in labour productivity. It is possible that labourers work less, but still produce more due to the new machines used. In such case, the single factor productivity fails to take into consideration the use of other factors in the production processes.

A more comprehensive measure of the efficiency of production process is to use the ratio of output to aggregate inputs. This is the basic concept behind the total factor productivity (TFP). TFP measures the productivity of a composite of all factors of production, mainly by looking at the contribution of capital and labour. It is measured relative to a base point. TFP reflects the efficiency with which factors of production are jointly used to produce the output.

Total productivity (TP), on the other hand, measures the efficiency of production process by taking into consideration the total output divided by the total inputs at a specified time (Oguchi, N., Faculty of Commerce, Shensu Univ., pers. comm. 2004). Using this measurement, comparison of the efficiency level of firms within a commodity and across commodity could be made. The efficiency of individual farms involved in planting watermelon for example, in the operation year 2004 could be compared. The comparisons of the efficiency of the watermelon, papaya and the pineapple sub-sectors could also be made for a specified year.

Efficiency measurement A production function (PF) is a quantitative or mathematical description of the various technical production possibilities faced by a firm. The PF gives the maximum output (s) in physical terms for each level of the inputs in physical term. There is a frontier setting a limit to the maximum possible output which could be obtained. A firm producing less than the maximum possible output lies below the production frontier and is regarded as inefficient.

There are four popular methods used for measuring and computing technical efficiency (Farrel 1957; Forsund et al. 1980). Most of the methods involve the construction of a best-practice frontier and the measurement of inefficiency relative to this frontier. The first method involves the construction of a deterministic non-parametric frontier sometimes called the pure programming approach (Farrel 1957). The second approach which was first suggested by Farrel (1957), involves the construction of a deterministic parametric frontier. It has been continued by Aigner and Chu (1968) and Forsund and Hjalmarsson (1974). The third approach, as proposed by Afriat (1972), uses statistical techniques to estimate a deterministic statistical frontier. Another approach of determining technical efficiency involves the estimation of a stochastic parametric frontier using specified functional forms and uses statistical techniques to estimate the frontier (Schmidt and Lovell 1979).

Model specification

Total productivity In this study, the TP approach is adopted to measure the individual watermelon farm efficiency within the sub-sector in the year 2004/2005. The TP model is represented as

$$TP_{T2004} = \frac{\text{Output}}{\text{Input}} = \frac{\Sigma PiQi}{\Sigma pij.qij} \quad (1)$$

Where,

TP = total productivity;
$_T$ = commodity watermelon;
$_{2004}$ = in the year 2004/2005;
i = individual farm/firm, i = 1……..49;
j = input, j = 1……m;
P = output price;
Q = output quantity;

p = input price; and
q = input quantity.

Technical efficiency The deterministic statistical frontier proposed by Afriat (1972) was used to determine the efficiency of the firms. This approach involves the assumptions of functional forms (usually Cobb-Douglas) for the frontier and estimations using the corrected ordinary least square (COLS) procedure. The functional form was first estimated using ordinary least square procedure (OLS), and then the constant term was corrected by shifting it up until no residual was positive and at least one was zero. The extent of a particular observation inefficiency was measured by the ratio of actual output to potential output, with the latter given by the frontier itself.

The frontier production function Mathematically, the non-linear Cobb-Douglas function is written as

$$Y = f(x)\, e^{u} \qquad \mu \leq O \qquad (2)$$

To estimate the function using OLS, the function has to be transformed into linear form,

$$\ell n\, Y = \alpha + \sum_{i=1}^{n} ßi\, \ell n\, Xi \qquad \mu\, i \leq O \qquad (3)$$

Where, Y = output;
α = intercept;
ßi = estimated coefficients;
Xi = set of input variables; and
μ i = one-sided residual.

In this study, the output was specified as the gross income (INC) of the individual farms in one crop cycle during the 2004/2005 operation year. The input variables were the cost of capital (CAP), the cost of labour (LABOUR) and the cost of other inputs (OTH) which included costs of seeds, fertilizers, insecticides, herbicides and plastic covers in the specified period of operation.

Measure of technical efficiency Kopp's measure of technical efficiency (TE) compares the actual level of input used with the level that could be used if a firm is operating on the frontier, given the actual output generated by the firm using the same ratio of input. Timmer's measure of TE for a specific firm is defined as the ratio of actual output to potential output, given the levels of input used by that particular firm. This measure indicates the amount of extra output that could be obtained if a firm is operating on the production frontier.

To generate Kopp and Timmer's TE measures, denotes CAP*, LABOUR*, and OTH* as the optimal usage of inputs CAP, LABOUR and OTH respectively. For each firm, for the given output INC,

$$\ell n\, CAP^* = \frac{\ell n\, INC - \alpha_1 - \beta_1\, \ell n \frac{LABOUR}{CAP} - \beta_2\, \ell n \frac{OTH}{CAP}}{\sum_{i=1}^{n} bi}$$

Where,
$\alpha_1 = \alpha + U_{max}$
ℓn LABOUR* and ℓn OTH* can be calculated in a similar way.

$$\text{Kopp TE} = \frac{CAP^*}{CAP} = \frac{LABOUR^*}{LABOUR} = \frac{OTH^*}{OTH} \leq 1 \quad (4)$$

The technically efficient firm will have CAP* = CAP, LABOUR* = LABOUR, and OTH* = OTH, while other firms tend to use input more than required.

$$\text{Timmer TE} = \ell n\, INC - \ell n\, INC^* = \frac{INC}{INC^*} \leq 1 \quad (5)$$

The technically efficient firm will meet the constraint INC* = INC. The other firms tend to produce output less than their potentials.

Results and discussion
The data used in this study consisted of production information on samples of 49 farms involved in producing watermelons (two seasons) in the operating year 2004/05.

Background of the respondents The 49 respondents involved in the study were selected from the districts of Kluang, Kota Tinggi, Muar and Pasir Putih. Most of the respondents were Malays in the age group of 40–60's and most of them had completed their secondary education. The gross monthly income for most of the respondents was between RM500–RM1,000. A majority of the respondents had 4–9 family members living with them, and most of them owned 0.4–1.6 ha of land *(Table 1)*.

Background of the farms The most popular varieties planted were *New dragon* followed by *Hitam Manis, Quality* and other varieties. Out of the 49 farms, 8 farms were categorised as big farms with the planted acreages of 8 ha and more. The rests were small farms with an area of 0.4–1.6 ha. Most of the respondents (65%) rented the lands from the owners while the others were using their own land *(Table 2)*.

Capital About 22% of the respondents indicated having tractors to help in the operation specifically for land preparation. The most common equipment available was sprayers which were owned by about 76% of the respondents. Irrigation system was critical in watermelon cultivation especially during hot season and more than 55% of the respondents were having them either on their own or subsidised by the DOA. Other capital items that contributed to the watermelon farming activities were buildings and transports. The buildings were mostly farm shades and the transports were mostly motorcycles. The value of the capital items are depicted in *Table 3*.

Labour The summary statistics of the numbers and costs of labour in watermelon production based on the sample farms are shown in *Table 4*. The labour work force was classified into family labour, wage labour and contract labour. In the small farms, contract labour was usually employed during the land preparation. Both family labour and wage labour were equally important in watermelon cultivation especially during the harvesting.

Input costs The inputs relevant to the watermelon production are seeds, fertilizers, pesticides, herbicides and plastic covers for weed control. The summary statistics for the total input costs is shown in *Table 5*.

Other costs The other costs which are not directly involved in watermelon cultivation are cost of land (land tax or rental), insurance and tax (vehicles), fuel (vehicles and machinery), repair (vehicles, machinery, etc), depreciation and others not classified elsewhere. However, these expenses were included in the calculation of TP *(Table 6)*.

Yield and revenue Depending on the farm size, the gross yield from each farm ranged from a low of 6,800 kg to a high of 633,200 kg per crop cycle. The average yield per ha was about 21,700 kg. The average yield per ha for both the big and small farms was consistent *(Table 7)*.

Depending on the variety and quality of the watermelon produced, the farm-gate price ranged from a low of 20 sen per kg for the seeded variety to a high of 80 sen per kg for the seedless variety. The average income per ha was about RM10,900. However, the average margin per ha for the small farms was about RM6,700, which was relatively higher than that of the big farms which has an average margin of about RM4,500 *(Table 8)*.

Contribution of labour and capital to income For the overall sample farms, the average contribution of labour to income was relatively higher than the average contribution of capital, which was 55% and 45% respectively. The average contribution of capital to income for the big farms was relatively higher (53%) than labour (47%). However, the average contribution of labour to income for the small farms as expected was higher (57%) than the contribution of capital (43%). The investment in capital in the big farms as expected was higher than that of the

Table 1. Summary of the socio-economic variables for the sample of 49 respondents involved in watermelon cultivation in 2004/05

Variables	Per cent by categories	Total no. of respondents
Districts	Kluang = 10.2% Kota Tinggi = 4.08% Muar = 2.04% Pasir Puteh = 83.67%	49
Age (years)	≤30 = 4.65% 31–40 = 20.93% 41–50 = 39.53% ≥50 = 34.88%	43
Ethnic	Malay = 83.67% Chinese = 14.28% Others = 2.04%	49
Education	SPM/STPM = 42.22% PMR = 26.66% Sekolah rendah = 28.83% Others = 2.22%	45
Gross monthly income (RM)	≤ 500 = 4.25%] 501–1,000 = 53.19% 1,001–2,000 = 25.53% ≥ 2,000 = 17.02%	47
Family members (stay together)	≤ 3 = 8.33% 4–6 = 47.92% 7–9 = 41.66% ≥ 10 = 2.08%	48
Land ownership (ha)	≤ 0.4 = 10.25% 0.4–1.2 = 56.40% 1.25–2.0 = 20.51% ≥ 5 = 12.82%	39

Table 2. Summary of the varieties planted, area planted and land tenured in a sample of 49 watermelon farms in 2004/05

Variables	Per cent by categories	Total no. of respondents
Varieties	New dragon = 30.61% Hitam manis = 20.40% Quality = 12.24% Others = 36.73%	49
Area planted* (ha)	0.4 – 0.8 = 55.10% 0.85 – 1.20 = 24.48% 1.25 – 1.60 = 4.08% ≥ 8 = 16.32%	49
Land tenure	Own land = 24.48% Rent = 65.30% Others = 10.20%	49

*≥ 8 ha = Big farms
< 8 ha = Small farms

Table 3. Status of capital in a sample of 49 watermelon growers in 2004

Capital item	Estimated value (RM)	Percentage of respondents having the item (%)
Building	29,500	24.48
Transport	1,122,610	73.46
Machinery and equipment	229,583	75.71
Irrigation system	124,945	55.10

Table 4. Summary statistics of the labour and its costs in a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics			Total no. of respondents
	Min.	Max.	Mean	
Family labour (no.)				
Big farms	0	0	0	8
Small farms	0	40	3.29	41
Overall farms	0	40	2.76	49
Wage labour (no.)				
Big farms	0	10	7.6	8
Small farms	0	5	1.76	41
Overall farms	0	10	2.71	49
Contract labour (no.)				
Big farms	0	40	6.5	8
Small farms	0	1	0.05	41
Overall farms	0	40	1.06	49
Labour costs (RM)				
Big farms	6,540	28,180	18,590	8
Small farms	578	4,465	1,593	41
Overall farms	578	28,180	4,368	49

small farms (*Table 9*). The contributions of both capital and labour were equally important in the watermelon sub-sector.

Total productivity The TP of an individual farm ranged from a low of 0.66 to a high of 4.91 (*Table 10*). The mean productivity for the watermelon farms was 2.05. The small farms were found to be relatively more productive than the big farms with the mean productivity of 2.10 and 1.80 respectively (*Table 11*).

Most of the farms were operating at the TP>2–3 (43%), followed by the TP>1–2 (38%). The rests were either having high TP or not productive (*Table 12*). The total output divided by the total input for all the 49 sample farms, gave a TP of 1.78 for the watermelon sub-sector, which was considered as high for an active investment. However, the TP of watermelon in the year 2004 was relatively higher than the TP in 2000 (1.36). This could be due to better crop husbandry, good variety and quality seeds. As has been mentioned earlier, water is critical in watermelon cultivation and more than 55% of the farms were irrigated using drip system. This factor contributed to improving TP.

Socio-economic factors influencing productivity OLS procedure was used to determine factors that affect the TP of the watermelon farms. The dependent variable was specified as productivity indices ($PVITI^T$) and the independent variables were the respondent age (AGE^T), area planted ($ACRE^T$) and gross

Table 5. Summary statistics of the input costs involved in a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics (RM)			Total no. of respondents
	Min.	Max.	Mean	
Big farms				8
Seed costs	1,500	7,250	3,417	
Fertilizer costs	4,000	57,210	26,576	
Pesticide costs	2,690	43,000	13,107	
Herbicide costs	0	3,360	1,250	
Plastic costs	0	37,440	10,811	
Total	16,830	101,190	55,162	
Small farms				41
Seed costs	100	900	421	
Fertilizer costs	272	3,080	1,172	
Pesticide costs	78	551	228	
Herbicide costs	0	338	69	
Plastic costs	312	1,225	511	
Total	1,406	4,495	2,403	
Overall farms				49
Seed costs	100	7,250	910	
Fertilizer costs	272	57,210	5,319	
Pesticide costs	78	43,000	2,331	
Herbicide costs	0	3,360	1,262	
Plastic costs	0	37,440	2,193	
Total	1,406	101,190	11,017	

Table 6. Summary statistics of other costs (RM) involved in a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics			Total no. of respondents
	Min.*	Max.	Mean	
Land	nil	8,250	462	49
Insurance and tax	nil	3,137	236	49
Fuel	nil	9,596	665	49
Repair	nil	7,000	279	49
Depreciation	nil	4,433	998	49
Others	nil	460	28	49

*Indicates that some respondents did not pay for the variables

monthly income (INC^T). The estimated regression model is shown in the equation (6). The figures in parenthesis indicated the t-values of the estimated coefficients.

$$PVITI^T = 2.4720 - 0.0093\,AGE^T - 0.0353\,ACRE^T + 0.0001\,INC^T \quad (6)$$
$$(7.256) \quad (-1.335) \quad (2.523) \quad (2.729)$$

Where,

$PVITI^T$ = productivity indices for individual farm;
AGE^T = age of individual farmer;
$ACRE^T$ = acreage of individual farm;
INC^T = gross monthly income for individual farmer;
R^2 = 0.1911
r = 0.4371, p = 0.05

Table 7. Summary statistics of the gross yield, yield and price of a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics			Total no. of respondents
	Min.	Max.	Mean	
Gross yield (kg)				
Big farms	170,000	633,200	313,518	8
Small farms	6,800	38,134	19,801	41
Overall farms	6,800	633,200	67,755	49
Yield (kg/ha)				
Big farms	11,900	32,200	22,000	8
Small farms	8,525	47,100	21,654	41
Overall farms	8,525	47,100	21,700	49
Price (sen/kg)				
Big farms	25	75	50	8
Small farms	20	80	50	41
Overall farms	20	80	50	49

Table 8. Summary statistics of the gross income, income per ha and margin per ha of a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics (RM)			Total no. of respondents
	Min.	Max.	Mean	
Gross income				
Big farms	69,600	314,790	145,020	8
Small farms	3,100	25,210	10,234	41
Overall farms	3,100	314,790	32,240	49
Income per ha				
Big farms	4,292	17,344	9,941	8
Small farms	3,830	30,900	11,100	41
Overall farms	3,830	30,900	10,900	49
Margin per ha				
Big farms	–1,480	10,986	4,515	8
Small farms	–904	24,987	6,706	41
Overall farms	–1,480	24,987	6,348	49

The farmer's age and the farm size tend to have negative influence on productivity. Younger farmers and small farm sizes were found to be more productive than the older farmers and the big farms as seen in the survey. Younger farmers tend to be more responsive towards new technology and innovation. Unlike the older farmers, they usually have the energy required to undertake farm activities.

Watermelon is a short-term and risky crop that needs intensive crop husbandry. Small farms would be easier to look after to ensure their productivity than big farms. However, the gross monthly income of the farmers positively influenced the productivity. The farmers with higher gross monthly income tend to be more productive than those with lower gross monthly income. Those with better income would have the resources needed to acquire sufficient inputs in their farm operations, thus increasing their productivity. The R^2 for the estimated model was 0.19 (r = 0.4371) which is considered as acceptable for a cross-sectional data. This means that 19% of the variations in the productivity indices could be explained by the three

Table 9. Summary statistics of costs for capital, labour and their contributions to income

Variables	Summary statistics			Total no. of respondents
	Min.	Max.	Ave.	
Capital cost (RM)				
Big farms	7,000	40,500	22,389	8
Small farms	0	55,085	4,278	41
Overall farms	0	55,085	7,235	49
Labour cost (RM)				
Big farms	6,540	28,180	18,590	8
Small farms	578	4,465	1,593	41
Overall farms	578	28,180	4,368	49
Share of capital in income (%)				
Big farms	0.37	0.74	0.53	8
Small farms	0	0.97	0.43	41
Overall farms	0	0.97	0.45	49
Share of labour in income (%)				
Big farms	0.26	0.63	0.47	8
Small farms	0.03	1.00	0.57	41
Overall farms	0.03	1.00	0.55	49

Table 10. The total productivity of a sample of 49 watermelon farms in 2004/05

Code no.	Input (RM)	Output (RM)	Total productivity
T2	119235	93675	0.79
T3	34226	69600	2.03
T4	68595	82800	1.21
T5	67377	74700	1.11
T6	132138	86850	0.66
T7	105685	245685	2.32
T8	65646	192067	2.93
T9	93891	314790	3.35
T10	7120	11850	1.66
T11	8476	25210	2.97
T12	5105	5989	1.17
T13	8055	19120	2.37
T14	3428	5858	1.71
T15	4138	6804	1.64
T16	5727	11660	2.04
T17	4928	11462	2.33
T18	6669	8050	1.21
T19	5749	7180	1.25
T20	5054	9750	1.93
T21	4226	9820	2.32
T22	3054	4757	1.56
T23	3108	5330	1.71
T24	4414	4348	0.99
T25	3298	5770	1.75
T26	3385	9180	2.71

(Cont.)

Table 10. *(Cont.)*

Code no.	Input (RM)	Output (RM)	Total productivity
T27	2924	9420	3.22
T28	4088	10439	2.55
T29	4786	10188	2.13
T30	6739	8602	1.28
T31	4021	8730	2.17
T32	5691	15700	2.76
T33	7272	20722	2.85
T34	4156	9314	2.24
T35	3553	7100	2.00
T36	6305	10000	1.59
T37	4658	10011	2.15
T38	6839	21447	3.14
T39	5100	25017	4.91
T40	4641	5420	1.17
T41	2634	4600	1.75
T42	5710	9775	1.71
T43	4226	8672	2.05
T44	3135	4617	1.47
T45	4197	3100	0.74
T46	3095	8759	2.83
T47	4853	10435	2.15
T48	3639	8946	2.46
T49	4825	8700	1.80
T50	4918	17747	3.61
Minimum	2634.00	3100.00	0.66
Maximum	132138.00	314790.00	4.91
Mean	18055.97	32240.14	2.05
Std. deviation	32740.76	61996.29	0.8248

$$\text{Total productivity} = \frac{\Sigma\text{Total output}}{\Sigma\text{Total input}} = \frac{1,579,766.70}{884,742.50} = 1.78$$

Table 11. Summary statistics of the total productivity of a sample of 49 watermelon farms in 2004/05

Variables	Summary statistics (RM)			Total no. of respondents
	Min.	Max.	Mean	
Big farms	0.66	3.35	1.80	8
Small farms	0.74	4.91	2.10	41
Overall farms	0.66	4.91	2.05	49

Table 12. Productivity level of a sample of 49 watermelon farms in 2004/05

Productivity level	Index	Percentage of farms	Total no. of respondents
Not productive	<1	8.16%	49
Low	1–<2	38.77%	49
Medium	2–<3	42.85%	49
High	≥3	10.20%	49

independent variables, where the F-value is 26.40.

Efficiency analysis Using the primary survey data collected from 49 watermelon farms, the average Cobb-Douglas production function was estimated using OLS (7).

$$\ell n\ INC = \underset{(5.099)}{2.3534} + \underset{(4.952)}{0.6055}\ \ell n\ LABOUR + \underset{(2.829)}{0.1056}\ \ell n\ CAP + \underset{(2.131)}{0.2371}\ \ell n\ OTH \quad (7)$$

Where,

INC	=	gross income for each individual farm in one crop cycle;
LABOUR	=	total labour cost
CAP	=	cost of capital for each individual farm in one crop cycle;
OTH	=	cost of other inputs for each individual farm in one crop cycle;
R^2	=	0.8691;
F – value	=	7.5056;
μ max	=	0.8124.

The letters ℓn in front of each variable represent natural logarithm and μ max denotes the largest positive estimated residual recorded by one of the sampled farms. Figures in brackets indicate the t-values of the regression coefficients.

All the independent variables (CAP, LABOUR and OTH) were found to be significant in explaining the variation in the dependent variable (INC). However, labour was found to be the most important factor influencing production and income, followed by other inputs and capital. The watermelon industry could be identified as a labour and input driven sub-sector with a still relatively low capital investment. The R^2 for the equation was 0.8691 which means that almost 87% of the variation in income could be explained by the three independent variables, where F-value equals 7.70.

COLS procedure was used to shift the intercept of the function until no residual was positive and at least one was zero to get the frontier function. After the appropriate shift, and denoting INC* as the maximum attainable output value from the given level of input used, the estimated frontier function was as in equations (8) and (9).

$$\ell n\ INC^* = 3.1659 + 0.6055\ \ell n\ LABOUR + 0.1056\ \ell n\ CAP + 0.2371\ \ell n\ OTH \quad (8)$$

or

$$INC^* = 23.7100\ LABOUR^{0.6055}\ CAP^{0.1056}\ OTH^{0.2371} \quad (9)$$

Measure of technical efficiency The Kopp and Timmer technical efficiency computed for the 49 sample farms is shown in *Table 13*. The ranking of efficiency levels was the same for both measurements. The sample of farms has a mean efficiency level of 0.46 with standard deviation of 0.19. From the table, it is clear that approximately 20% of the observation were at least 60% efficient and 35% were at least 50% efficient. About 55% of the sample farms were having efficiency level below the average.

The frontier and actual usage of inputs for the sample farms are presented in *Table 14.*

In general, the sample farms were using inputs higher than required, thus reducing the technical efficiency.

The average efficiency of about 46% would indicate that there is room for improving its average efficiency level to at least 50% efficient, in order to be competitive in the 'glocal' markets.

The average efficiency for the manufacturing sector from 1992–2001 was about 56% (Nor Aini 2004), whereas the average efficiency for the apparel industry for the same period was about 56% (Mohd. Anuar and Faridah 2004).

Conclusion and recommendations

This study revealed that the TP of the watermelon sub-sector in the year 2004/05 was 1.78 which was relatively higher than the TP of the crop in the year 2000 at 1.36, an increase of about 30%. The return of 78% is considered favourable for an active investment. The sample farms had a mean efficiency level of 46% which was considered as acceptable for a high risk agriculture investment.

There are opportunities to maintain and improve the farms' productivity and efficiency either by reducing the production costs and/or increasing the yield and revenue.

The farm-gate price for watermelon was found to be fluctuating depending on demand and supply. For the seeded variety, the price could be as low as 20 sen/kg. Watermelons are high in demand during hot season especially during the fasting month of Ramadan. Demand for watermelons will be very much affected during heavy fruit seasons and during rainy season. Thus, the farmers together with the assistance of the extension agents should plan in advance the appropriate time to produce the crop in order to get a better price and high revenue, thus increasing their farms' productivity level.

Watermelon can be categorised as labour intensive and input driven sub-sector with relatively low investment in capital assets. Labour and fertilizer constituted 37% and 30% respectively of the variable costs. Thus, the productivity of the sub-sector could be improved further by increasing capital utilisation, particularly by the use of the irrigation system. The use of the irrigation system, in general could contribute to higher farm productivity as the labour cost for watering the plants especially during early crop establishment could be reduced significantly. More than 50% of the farmers surveyed were having the equipment either through government subsidy or self acquisition. The government should thus extend its support programme to all watermelon growers who are in need of the facilities by providing a credit scheme to acquire the irrigation system. Priority should be given to younger farmers with higher education level who were more productive based on the study. Consideration should also be given to small scale growers which were more productive than the large scale growers as shown in the survey. This recommendation is in line with the government policy to increase the participation of young graduates in agricultural activities considering the scarcity of suitable land resource.

There is an indication of excessive used of material inputs particularly fertilizer in the watermelon cultivation. Fertilizer application at an optimum level could improve the productivity and technical efficiency of watermelon at the farm level.

The average yield of watermelon (21,700 kg/ha per season) was considered low as compared to the average yield of the crop in China, our close competitor (about 33,360 kg/ha per season). From the survey, the maximum attainable yield by one of the respondent was about 46,950 kg/ha, which was much higher than the average yield of the crop in China. There is a great possibility that the yield of watermelon in this country could be improved further by adopting superior variety and quality seeds. At this moment, the farmers are dependent on imported seeds. There are many varieties to choose and the farmers usually rely on recommendations from seed suppliers. The R&D personnel should also be working together with the extension agents in identifying the most viable and profitable variety for higher farm productivity.

Table 13. Measures of the technical efficiency in a sample of 49 watermelon farms

Rank no.	Kopp TE	Timmer TE
1	1.0015	1.0013
2	0.9052	0.9098
3	0.8850	0.8906
4	0.7659	0.7766
5	0.7591	0.7700
6	0.6788	0.6925
7	0.6673	0.6815
8	0.6560	0.6705
9	0.6366	0.6516
10	0.6351	0.6502
11	0.5856	0.6021
12	0.5612	0.5783
13	0.5402	0.5577
14	0.5154	0.5334
15	0.5147	0.5327
16	0.5146	0.5326
17	0.5093	0.5274
18	0.4938	0.5122
19	0.4907	0.5091
20	0.4786	0.4972
21	0.4713	0.4901
22	0.4612	0.4801
23	0.4524	0.4714
24	0.4448	0.4638
25	0.4445	0.4635
26	0.4286	0.4479
27	0.4271	0.4464
28	0.4269	0.4462
29	0.3835	0.4031
30	0.3833	0.4028
31	0.3525	0.3720
32	0.3524	0.3719
33	0.3486	0.3682
34	0.3482	0.3677
35	0.3481	0.3676
36	0.3370	0.3565
37	0.3311	0.3506
38	0.3151	0.3345
39	0.3099	0.3293
40	0.2958	0.3151
41	0.2898	0.3090
42	0.2790	0.2981
43	0.2733	0.2923
44	0.2732	0.2922
45	0.2652	0.2841
46	0.2578	0.2766
47	0.2134	0.2312
48	0.1587	0.1746
49	0.1457	0.1610
Mean	0.4615	0.4785
Standard deviation	0.1899	0.1865

Table 14. Actual and frontier usage of inputs in a sample of 49 watermelon farms

Rank no.	Actual usage (RM)					Frontier usage (RM)		
	ID	INC	LABOUR	CAP	OTH	LABOUR*	CAP*	OTH*
1	T39	25017	2058	81	2735	2060	81	2738
2	T27	9420	578	81	1705	523	73	1543
3	T9	314790	28180	4208	42030	24939	3724	37197
4	T46	8759	950	10	1746	727	7	1337
5	T8	192067.5	21522	2785	23112	16338	2114	17544
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
45	T6	86850	15650	4308	101190	4151	1142	26843
46	T2	93675	19174	4433	91675	4944	1143	23638
47	T40	5420	1690	269	2026	360	57	432
48	T24	4348	1898	223	2108	301	35	334
49	T45	3100	1336	100	2497	194	14	447

The production technology for watermelon is available. This is indicated by the high productivity and efficiency achieved by some of the growers. Perhaps the successful farmers should become models for others to emulate.

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Abstrak

Temu bual bersemuka yang melibatkan 49 penanam tembikai bagi dua musim penanaman dalam tahun 2004/2005 telah dilaksanakan dengan objektif menilai produktiviti dan kecekapan ladang. Analisis data menunjukkan produktiviti total (TP) bagi tiap-tiap ladang mempunyai nilai antara 0.66 dan 4.91. Produktiviti total purata bagi sampel ladang ialah 2.05 dan bagi sub-sektor tembikai pada 2004/2005 ialah 1.78. Secara purata, sumbangan buruh kepada pendapatan lebih tinggi berbanding dengan sumbangan kapital. Prosedur ganda dua terkecil biasa (OLS) yang dibuat menunjukkan petani muda dan yang berpendapatan lebih tinggi, masing-masing lebih produktif daripada petani yang berumur dan berpendapatan rendah. Kecekapan teknikal (TE) ukuran Kopp dan Timmer yang dikira menunjukkan sampel ladang beroperasi pada tahap kecekapan purata 46% dengan sisihan piawai 0.18. Ruang bagi membaiki produktiviti dan kecekapan sub-sektor ini boleh dicapai dengan meningkatkan hasil dan pendapatan melalui penggunaan teknologi baru, varieti baru dan benih yang baik dan mengurangkan kos pengeluaran. Pemasangan sistem pengairan di ladang tembikai sangat disyorkan bagi mengurangkan kos buruh menyiram tanaman dan juga bagi memastikan pengeluaran hasil yang baik.