Economic and Technology Management Review, Vol. 16(2021): 21 – 32

The economic potential of first hybrid rice variety (KADARIA 1) adoption in Malaysia

(Potensi ekonomi penggunaan varieti pertama padi hibrid (KADARIA 1) di Malaysia)

Hairazi Rahim*, Mohd Solihen Jamal**, Engku Elini Engku Ariff* and Syahrin Suhaimee*

Keywords: KADARIA 1, hybrid rice cultivation, cost benefit analysis (CBA), hybrid seed production, partial budgeting

Abstract

The latest innovated hybrid rice known as KADARIA 1 was released and been evaluated in term of yield performance at selected granary areas in Peninsular Malaysia. Though this advanced technology of variety was developed for more than 30 years in other countries, it is relatively new in Malaysia as the technology recently have been explored in less than 10 years. Hybrid type offers a lot improvement in rice yield performance, therefore many countries invested extensively in developing more advanced hybrid seed packages for their farmers. It is notable that the cost of hybrid seed production was higher as compared to the inbred variety type. In addition, the stagnant profit margin due to the low technical efficiencies and decreasing return to scale of elasticities in number of national granaries as well as increasing in production costs in rice cultivation put some critical consideration for new alternatives to be explored. Therefore, this study attempt to determine the potential benefits if hybrid type rice is to be adopted in those granaries since the first hybrid rice variety has been successfully developed namely KADARIA 1. However, this study found that the initial efforts to put hybrid in granaries are quite difficult since the average yield produced (7.32 tonnes/ha) were not significantly different in comparison to the inbred type (6.23 tonnes/ha). Further, the benefit cost ratio (BCR) was not favorable if farmers happened to adopt KADARIA 1 for their farms. The benefit's margin is plummeted as soon as the hybrid rice price is not subsidized at RM15.00/kg from original estimated commercial price at RM22.29/kg, which implies the need for the government to subsidize the seed when farmers opted to grow hybrid. Even though the yield performance was not significant as evaluated in this study, the exploration in the development of the hybrid rice is undeniably vital considering the ability of this variety type is more resistant to the pest and diseases. The study found that hybrid use in both cultivation and seed production can be potentially implemented to the granaries if few requirements and improvements are to be met. It can be done either through the significant increases in yield performance or producing the hybrid's seeds economically; or both.

*Socio-Economy, Market Intelligence and Agribusiness Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor
**Paddy and Rice Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor
E-mail: hairazi@mardi.gov.my

Introduction

Guaranteeing the supply of food through increased productivity in agricultural production was in national agenda as emphasized since the 9th (9thMP) until the 11th Malaysia Plan (11thMP). For almost three decades, various efforts have been made by the government to achieve this goal. One of the important commodities that was always been given the priority in every government policy was rice. As the staple food for Malaysians, it is vital to ensure the sustainability of this commodity especially through the incentives and encouragement in adopting new technologies for productivity enhancement (Venkatesh and Davis 2000; Serin et al. 2019).

Despite experiencing significant increases in yield over the years, the rice industry at the same time faced the rising cost in production. It has been identified as one of the factors affecting the stagnant earning by farmers as the cost increases offset the yield increases. Over the last 5 years, the percentage of cost versus income (RM per ha) has shown an increase, which indirectly indicates that the status quo is no longer an option in maintaining the sustainability and competitiveness of rice cultivation in Malaysia (Rahim et al. 2019). For example, there was a 24% increase in the cost of production per hectare in rice cultivation within 3 years, from 2015 to 2017 at FELCRA Seberang Perak (DOA 2015).

As reported by Khan *et al*. (2016) in a study regarding profit efficiency in Muda Agricultural Development Authority (MADA) in Kedah, most of the farms were performing on an average however, cost efficiency of the farmers was below of the average. In certain national granaries, low percentage of Technical Efficiency (TE) and elasticities (<1) have been reported indicated the decreasing return to scale patterns which implies any additional inputs such as fertilizer, seed, pesticide, cultivation area and labor were not contribute enough to the increase in yield anymore (Abiola et al. 2016; Rahim et al. 2019).

Although the increase of certain inputs significantly affected the increase of yield per hectare in particular granaries, the overall trade-off value was found to be worthless even with the collective increase of these input units (Mailena et al. 2014; Rahim et al. 2020). Without intervention of technological advancement, the rice production which was strongly related to the efficiency and productivity level cannot be intensified (Parichatnon et al. 2017). Since the rice yield performance heavily relied on the series of inputs as has been outlined in the fundamental production function, the combination of upgraded important inputs alongside with the modernization in cultivation phases were undeniably important (Abidin et al. 2018).

Innovation in new rice variety such as hybrid instead of depending on the inbred type after decades is beyond question. Hybrid variety (seed) is known by its substantial yield performance as well as have greater resistant ability towards pest and diseases (Ni et al. 2015). Called as super high yielding rice when first initiated by Japan in 1982, the innovated hybrid rice which have been developed eight years later could not be adopted to large areas due to the lack of cold resistance, poor grain quality and low seed setting rate (Chen et al. 2007).

Later, series of 'super rice' (hybrid) by few research institutions such as IRRI and other related rice research institutes successfully been developed but failed to be adopted in the larger fields due to various deficiencies. China took the challenge and finally produced first generation of 'super hybrid rice' by 2005 which yielded 15% more higher as compared to the inbred. Currently, the combinations of super hybrid rice that widely planted in the vast amount of Chinese soil came from the first-generation ancestors of the 2005 success.

Background of the study

Hybrid rice is the first generation (F_1) rice progeny, derived from crossing between two genetically distinct rice lines. Generally, hybrid rice is bred to increase yield potential, disease resistance and grain quality through the exploitation of a biological phenomenon known as heterosis where the performance of the first offspring better than both parents. In China, this technology has been proven to have a 20% yield advantage over inbred rice (Yuan 2004). Meanwhile for other countries, the yield advantage of hybrid rice over inbred variety was about 15 - 20 percent (Virmani 2003). Thus, this technology could be an alternative in the efforts to increase the yield performance in our cultivated land. According to Xie and Hardy (2009), in 2007 it is estimated that 2.8 million hectares of commercial rice hybrids were grown in the countries outside of China, namely Bangladesh, Brazil, India, Indonesia, the Philippines, Vietnam and the United States.

There are two main important elements in hybrid rice technology development namely variety and seed production. Once the variety is ready, the seed producer has to produce the hybrid seed on a large scale for commercial hybrid cultivation by the farmers. Apart, analysis of the economic viability of the hybrid seed production is an important indicator in ensuring that the viability of hybrid rice seed production is applicable in field (Dalrymple 1986). The surplus benefits (yields per hectare) that exceeds the cost is to ensure the production of hybrid rice seeds is economical to implement.

The process of hybrid rice seed production is complex and strict, with low efficiency and high labor cost (Singh et al. 2018). All of these factors have resulted in high prices of hybrid rice seed. In addition, it requires specific skills and experience from various practices in order to maximize the returns while minimizing the cost in production. China, for instance took many years of experience to achieve F_1 seed yield at 2.5 t/ha as compared to the beginning of its commercial production where the average yield was less than 0.5 t/ha in the late 1970s (Virmani et al. 2002).

Generally, hybrid rice has the potential to increase yield by 15 to 20 percent per hectare as compared to the inbred variety. Thus theoretically, the cultivation of hybrid rice will benefit farmers with more monetary benefits. For example, a farmer group in West Nusa Tenggara Province, Indonesia claimed that they have experienced an increase of income up to 30 percent compared to the inbred cultivation previously (Indra and Muhammad 2019). However, the agronomic practice for hybrid rice cultivation is slightly different from the inbred such as on the seed rate, transplanting method and fertilizer rate.

According to FAORAP and APSA (2004), considerations for adoption of hybrid rice are seed costs, quantity of seed required, quantity of complementary inputs required, labour requirements, yields, output price, and risk preferences and subjective probabilities. Therefore, cultivation of hybrid varieties is expected to have cost implications especially for the seed price, labour and additional fertilizer. Prior to that, valuation needs to be carried out in determining the economic feasibility of hybrid rice cultivation before it can be implemented by farmers.

The first hybrid rice variety has successfully been developed and launched by Malaysian Agricultural Research and Development Institute (MARDI) in 2019 namely KADARIA 1. It is an early maturing variety that can be harvested between 104 to 106 days after sowing. The amylose content is intermediate with medium-hard gel consistency which corresponds to flaky rice texture after it is cooked. This variety is resistant to leaf and panicle blast but moderately susceptible to bacterial leaf blight, sheath blight, rice tungro diseases, and brown plant hopper.

Moreover, this variety has been introduced among the farmers in Kemubu Agricultural Development Area (KADA) due to its good performance in the semi-fertile area.

The introduction of such new technology must come along with economic information through benefit cost analysis and market pricing projection of KADARIA 1 seed in order to help farmers in making their decision before adopting the technology. Thus, this study was carried out to determine the production cost and net return from the cultivation of hybrid rice and hybrid seed production. A good variety selection alongside with the proper management in every cultivation phase including levelling, seeding, fertilizer application, pests and diseases management until harvesting stages will determine the yield performance in rice cultivation. The analysis will feed the necessary information for the farmers to consider while helping the policy makers in steering the industry to a better direction.

Methodology

The main analytical framework of the study relied on the calculation of the performance in Benefit Cost Ratio (BCR) to provide a useful guidance in investment decision model by policy makers and farmers. BCR estimation under the Cost Benefit Analysis (CBA) is used by the internalization of total cost of production including variable costs to look at the feasibility of a project over a period of time (Ariff et al. 2011). The results from the CBA exercise should provide a comparison of revenue and cost of rice cultivation per hectare using hybrid rice. For the financial analysis, the cash flow statement for the viability of the rice project over a period of 10 years was performed. Based on these cash flow statements, calculations for financial analysis such as net present value (NPV), internal rate of return (IRR), Capital Return Period (CRP) as well as BCR, can be obtained (*Table 1*).

Furthermore, this exercise also included the hybrid seed production's viability evaluation covering 2 scenarios; the production of certified seeds by MARDI and also by private companies. Production cost's data consists of fixed and variable costs (operating costs). Fixed costs are development costs or capital costs that do not change with the production value. The variable cost refers to the direct cost involved in the production of rice seed and varies according to the level of production. Among these costs are the cost of pesticides for the control of diseases and insects, fertilizers and wages of workers.

The survey data for financial analysis of hybrid rice cultivation was obtained from the Local Verification Trial (LVT) plots from different sites. The trials

Table 1. Item Description of Financial Viability Analysis

No.	Trial Site	Granary Area	Trial Season	
			Season 1	Season 2
1	Tanjung Karang, Selangor	IADA Barat Laut Selangor	August-December 2018	February-June 2019
2	Arau, Perlis	MADA	October2018-February 2019	April-August 2019
3	Sanglang, Perlis	MADA	October 2018-February 2019	April-August 2019
4	Mulong, Kelantan	KADA	January-May 2019	June-October 2019
5	Teratak Pulai, Kelantan	KADA	January-May 2019	July-November 2019

Note: Integrated Agricultural Development Area (IADA), Muda Agricultural Development Authority (MADA) and Kemubu Agricultural Development Authority (KADA)

were carried out in 5 sites including few areas in Muda Agricultural Development Authority (MADA), Kemubu Agricultural Development Authority (KADA) and Integrated Agricultural Development Authority (IADA) Barat Laut Selangor as can be seen in *Table 2*.

Meanwhile, the information for hybrid seed production financial analysis was obtained from the KADARIA 1 seed production plots at MARDI Seberang Perai as can be seen in *Table 3*. In analyzing the production costs and returns of rice farmers in hybrid rice cultivation, there are some differences that need to be taken into consideration. This is because the use of hybrid rice requires the farmers to use the method of transplanting in cultivating the rice. As such, there is an increase in the cost of seed preparation and planting phases compared to the use of inbred seeds that commonly implemented direct seeding method.

Results and Discussions

Determining the Price of KADARIA 1 Hybrid Seed

An evaluation was conducted to look at the viability of hybrid rice seed production. This could lead the seed producer company to estimate the optimum selling price. The analysis shows that the minimum price of hybrid foundation seed is at 41 per kg for the further level of producing the certified seed. This minimum price is calculated by taking into account the minimum BCR of producing approximately 400 kg of foundation seed per hectare with the total cost of RM12,038 per ha.

The cost structure shows that 81.14% of total production cost was used as a labor cost while the remain as input cost. This means that, only one fifth of the total production cost for foundation seed is for input where most of the cost goes to the labor. As reported by Khushik et al. (2011), it is more expensive in producing

Table 2. Information of Local Verification Trial (LVT) Sites for KADARIA 1

Item	Details
Gross Income	Yield x price
Net Income	Gross income – total production cost
Total Production Cost	Variable costs + fixed costs + other costs
Capital Return Period (CRP)	The amount of time it takes to recover the original investment capital issued. The shorter the time it takes to recover the original capital, the better.
Benefit Cost Ratio (BCR)	Obtained by dividing the total income during the project by the total expenditure. BCR value shows the rate of return per RM invested. If the value of BCR exceeds 1, then the project will benefit.

Source: Ahmad (2008), Žižlavský (2014) and Zulkifli et al. (2016)

Table 3. Seed Production Phases for KADARIA 1

Phases	Variety/lines	Season
Nucleus seed	0025A, 0025B, 004R	Off Season 2019
Breeder seed	0025A, 0025B, 004R	Off Season 2019
Foundation seed	0025A, 004R	Off Season 2019
Certified seed	KADARIA 1	Off Season 2019

the hybrid foundation seed as compared to the conventional inbred varieties. This was driven by the complicated production phases in hybrid since it involves the multiplication of parental lines including cytoplasmic male sterile (CMS), maintainer and restorer (Mao et al. 1998).

With the production costs is above RM14,000 per ha, it is impossible to sell the certified hybrid rice seed at a price less than RM22.29 per kg (subsidy value as applied to the current inbred variety is included in the suggested price), either being produced by MARDI or potential private company. The cost structure also showed a high percentage of labor costs for both MARDI or private production at 59.41 per cent and 55.06 per cent respectively. The production of hybrid rice certified seed at 680 kg per hectare is expected. As reported by He et al. (1987) and He et al. (1988), the early years of hybrid rice certified seed production in China were between 0.375 to 1 tonne per ha (*Table 4*).

If the price is set at RM22.29 per kg for hybrid rice certified seed, the BCR ratio is expected to exceed the standard minimum rate of more than > 1 which means the minimum benefit can be enjoyed by the producer without considering other constraints such as potential environmental uncertainty and possible pests and diseases. Furthermore, the capital return period (CRP) is estimated to be in between 2 to 3 years if hybrid seed producers are to take up the proposition given.

Estimated Benefits from KADARIA 1 Adoption

The partial budgeting was done to estimate the benefits and implications of hybrid variety as compared to inbred. The analysis was done under two assumptions; with and without subsidy for the cost of seed. The data was obtained from the experimental plot as mentioned above. The analysis was based 10 ha of rice cultivation by comparing hybrid and inbred variety.

The comparison between two farmers that planted hybrid and inbred seed that owned the cultivation area and using transplanting method can be seen in the *Table 5* below. The gross yield for hybrid was estimated higher at 1,083 kg per hectare and the benefits gain by farmers for 10 ha of cultivation was at RM16,894.80 per cycle. If the assumption for hybrid seed cost is applied at RM22.29 per kg, the cost for hybrid seed per ha is at RM891.60 per ha as compared to the price of inbred seed at RM262.50 per ha. Farmers need to spend more of RM629.10 if they are planting the hybrid rice.

There is no difference in terms of operational cost, hence the hybrid seed is counted as an implication to the hybrid farmers. The results stated that the total benefit is higher than the total implications at RM797.88 per ha. It showed that hybrid might have a solution in future to increase farmers' production as well as increased their income. If the government are willing

Table 4. Estimated Cost of Production and Benefits of Hybrid Rice Production

Producer		Yield/ ha (kg)	Price (RM/kg)	Production cost (ha)			Financial viability	
				Total cost	Input (%)	Labor (%)	BCR	CRP (Years)
MARDI	Foundation seed	400.00	4.60	12,038	12.43	81.14	1.01	2.41
PRIVATE	Certified seed	680.00	22.29	14,595	38.75	55.06	1.04	2.36

Note: Proposed foundation seed and certified seed sale price is at a minimum based on production cost and positive financial viability (Primary data 2019)

to subsidize the hybrid seed at RM15 per kg, farmers will gain more benefits at RM1,089.48 per ha (*Table 6*). The study suggested approximately 35% to 42% discounted price for subsidized hybrid price, KADARIA 1 in reference to the percentage amount of subsidy given to the inbred variety.

Benefit and Cost Involved in KADARIA 1 versus Inbred Rice Variety

The benefit cost analysis showed the cost and return of the rice farmers which includes the subsidies provided by the government. The results will be reported in 3 scenarios: 'with subsidy', 'without subsidiy[a]' and 'without subsidiy[b]'. These scenarios have been presented to show

Table 5. Partial Budgeting for Non-subsidized Hybrid Seed Price (Estimated for 10 hectare)

Benefit (+)		Implication (-)	
Return Increase (RM)		Return Decrease (RM/ha)	
Yield higher at 1083kg/ ha*10 ha	10,830		
Rice price (RM/kg)	1.20		
Rice price subsidy (RM/kg)	0.36		
Total return (RM)	16,894.8	Total return (RM)	0
Cost Decrease (RM)		Cost Increase (RM)	
Operational cost	0	Non-subsidized hybrid seed @ RM22.29/kg	8,916
Total	16,894.8	Total	8,916
Total benefit	16,894.8	Total implication	8,916
Total benefit/hectare	1,689.48	Total implication/hectare	891.6
Total benefits – Total implications			7,978.8
Benefit per hectare			797.88

Table 6. Partial Budgeting for Subsidized Hybrid Seed Price (Estimated for 10 hectare)

Benefit (+)		Implication (-)	
Return Increase (RM)		Return Decrease (RM/ha)	
Yield higher at 920kg/ ha*10 ha	10,830		
Rice price (RM/kg)	1.20		
Rice price subsidy (RM/kg)	0.36		
Total return (RM)	16,894.8	Total return (RM)	0
Cost Decrease (RM)		Cost Increase (RM)	
Operational cost	0	Subsidized hybrid seed @ RM15/kg	6,000
Total	16,894.8	Total	6,000
Total benefit	16,894.8	Total implication	6,000
Total benefit/hectare	1,689.48	Total implication/hectare	600
Total benefits – Total implications			10,894.8
Benefit per hectare			1,089.48

that the rice production monetary benefits will be reduced if the subsidy policy is no longer provided to the rice sector. As farmers continue to cultivate the rice without incentives from the government, their financial flow will probably be decreased. Currently, the dependancy of rice farmers towards subsidy is to ensure a continuation of rice cultivation as part of food security recommendations. Due to that, the used of hybrid seeds though requires the additional cost for seed preparation and planting was aimed to produce higher yield as compared to inbred.

Within area of 1 hectare, it is estimated to produce an average yield of 7.32 metric tonnes per ha. The net production after 26 percent deduction; farmers will earn an average gross income of RM8,446.74 per hectare. The average increase in the gross yield of the hybrid rice was at 11% higher than the average yield of inbred, but in terms of cost, there was an increase in seed cost (40 kg per ha), as well as preparation and seeding approaches. Hence, increase in yield might not increase the average net income of the rice farmers if targeted additional yield cannot be achieved. Significant increase in costs (> RM891.60 per ha at least) affects the cost benefit ratio and net income of hybrid rice farmers (*Table 7*).

The average cost of hybrid rice production is RM4,753.21 (with subsidy) and RM5,927.61 (without subsidy[a]) when farmers did not receive any subsidies except for the hybrid seed price at RM15.00 per kg. Further, the average cost of hybrid production totally without subsidy even for the hybrid seed price at RM22.29 per kg would be RM6,219.21 per ha. Hybrid rice, the benefit cost ratio (BCR) showed at 1.78 (with subsidy), 1.42 (without subsidy[a]) and 1.36 (without subsidy[b]), respectively, compared to inbred (transplanting) rice which shows BCR values at 1.37 (without subsidy[a]) and 1.90 (with subsidy). In terms of yield, using direct seeding method, inbred produce lower yield and with subsidy the BCR value was at 1.98 whereas without

Table 7. Estimated Cost of Production and Return of Farmers by Comparing Hybrid and Inbred Rice Cultivation

Item		Transplanting		Direct seeding
		Hybrid	Inbred	Inbred
Area (ha)		1	1	1
Average Yield (tonnes/ha)		7.32	6.23	5.39
Net Yield (tonnes/ ha) (26% deduction)		5.41	4.61	3.99
Gross Income (RM/ha)		8,446.74	7,195.38	6,222.22
Production Cost (RM/ha)	With Subsidy	4,753.21	3,784.22	3,138.36
	Without Subsidy[a]	5,927.61	5,250.22	4,604.36
	Without Subsidy[b]	6,219.21	-	
Net Income (RM/ha)	With Subsidy	3,693.53	3,411.16	3,083.86
	Without Subsidy[a]	2,519.13	1,945.16	1,617.86
	Without Subsidy[b]	2,227.53	-	-
BCR	With Subsidy	1.78	1.90	1.98
	Without Subsidy[a]	1.42	1.37	1.35
	Without Subsidy[b]	1.36	-	-

Note:
[a] Exclude current subsidies amount received by farmers + subsidized hybrid seed price at RM15.00/kg at a rate of 40 kg per ha
[b] Exclude current subsidies amount received by farmers + subsidized hybrid seed with the same amount subsidy as current inbred variety, the price was estimated at RM22.29/kg at a rate of 40 kg per ha

subsidy was at 1.35. The better BCR performance for inbred type (with subsidy) as compared to hybrid, KADARIA 1 inevitably due to the lower production cost specifically in seed cost. However, the BCR values (without subsidy[a and b]) were better and net income (RM per hectare) from hybrid production surpassed the inbred in all scenarios. Simplified graphics information can also be referred as presented in *Figure 1* and *Figure 2*.

The findings of the economic feasibility study for hybrid rice cultivation and hybrid seed production provide important guidance especially for policy makers and farmers in the rice industry. Rice cultivation using hybrid seeds does not have a huge impact on yield performance and farmers will experience considerable amount of income surplus. In fact, the benefit cost ratio does not show a significant difference between the use of hybrid rice seeds compared to inbred rice varieties.

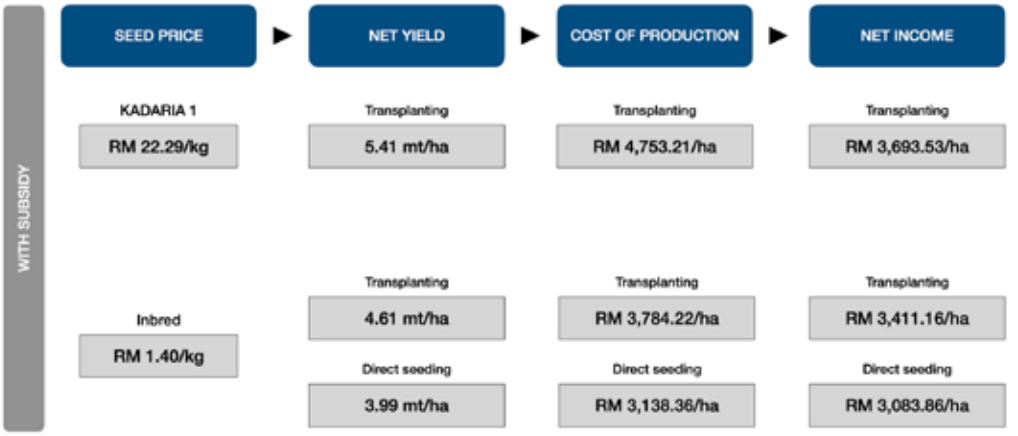

Figure 1. Cost and Benefit Comparison between KADARIA 1 and Inbred Rice Cultivation with Subsidy

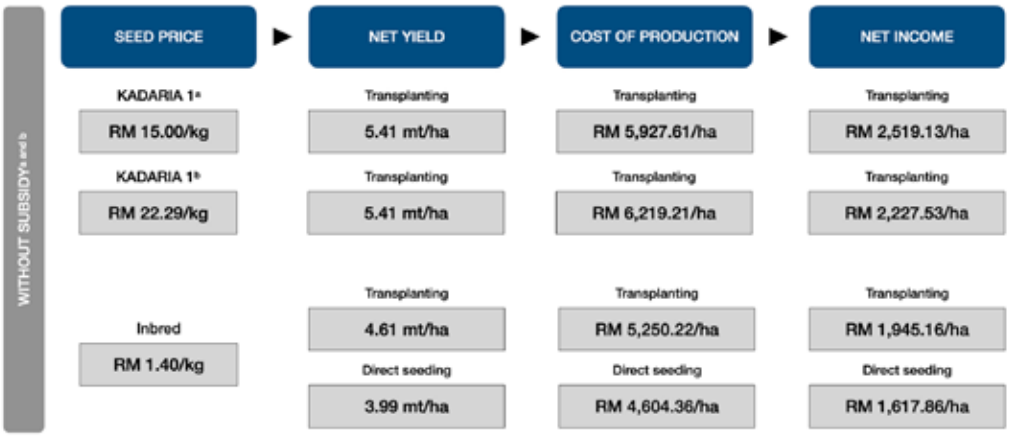

Figure 2. Cost and Benefit Comparison between KADARIA 1 and Inbred Rice Cultivation Without Subsidy[a and b]

However, the average increase in hybrid rice yields can be considered to be adopted in those areas with lower average production values for inbred rice with specific hybrid rice agronomic practices for optimal yield. The hybrid rice cultivation is suitable for few specific granaries which are considered to be already reached the optimal use of inputs but still unable to increase the yield per hectare. KADARIA 1 is profitable enough for those rice growers to opt to. It can be a very potential alternative when the average yield can be steadily optimized as well as to cope with uncertain environmental condition in the near future.

The production of hybrid rice seed is much more expensive as compared to the inbred seeds' production especially in term of labor cost at the foundation seed phase as well as certified seed production level. As reported by Virmani and Kumar (2004), the early stages of hybrid rice seed production will have such obstacles especially in the aspects of the increasing labor cost and low average seed production. This can be overcome by ongoing research in improving seed quality and the use of cost-effective new technologies for hybrid rice production. More complicated development phases in hybrid seed contributed to the higher costs. Continuous improvement in hybrid seed production with better quality, yield performance and economic however is undeniably important since the resistance ability has been proven to be beneficial in put a steady production of rice (Mao et al. 1998; Xie and Hardy 2009; Khushik et al. 2011) and will contribute to the food security of the nation.

Conclusion

Rice cultivation using KADARIA 1 will resulted in increase in costing structure especially in terms of the additional cost for the seeds. Related to that, transplanting method in seeding phase is required as a part of manual procedure that hybrid farmers have to follow. The results on comparison the benefits and implications between the hybrid and inbred varieties which were done using the same practices have portrayed a clear monetary impact if farmers were to adopt the KADARIA 1 for their rice cultivation. The results stated that, farmers that planted using hybrid seed will experience slightly higher yield per hectare with extra total benefits for each hectare of rice cultivation even without the subsidized hybrid seed. If there is no changes of the current subsidies and incentives framework from the government, the farmers will reap even more monetary benefits if they opted to change from the use of conventional inbred variety to the hybrid type. However, the changes from inbred into hybrid will be followed by the increase in cost. Therefore, the used of hybrid seed is practical to be introduced to farmers or locality with low productivity per hectare and the farmers must abide strictly with the KADARIA 1 cultivation manual and procedures.

References

Abidin, A.Z.Z., Rahim, H., Nazmi, M.S., Amin, M.Z.M., Omar, N.R.N., Nor, N.A.A.M., Muhammad, R.M., Rusli, R., Harun, R. and Ariff, E.E.E. (Eds.). (2018). Pertanian dan Pemprosesan Makanan: Di Manakah Tahap Teknologi Malaysia. Serdang, Selangor MARDI

Abiola, O. A., Mad, N. S., Alias, R. and Ismail, A. (2016). Resource-use and allocative efficiency of paddy rice production in Mada, Malaysia. *Journal of Economics and Sustainable Development*, 7(1)

Ahmad, T.A.T.M. (2008). MARDI Report submitted to the Ministry of Agriculture and Agro based Industry, Putrajaya, Malaysia.

Chen, L.Y., Xiao, Y.H., Tang, W. B. and Lei, D. Y. (2007). Practices and prospects of super hybrid rice breeding. *Rice Science*, 14(2): 71 – 77

Dalrymple, D.G. (1986). Development and spread of high-yielding rice varieties in developing countries: Int. Rice Res. Inst.

DOA. (2015). Pakej Teknologi Padi: Perpustakaan Negara Malaysia

FAORAP and APSA (FAO Regional Office for Asia and the Pacific and Asia-Pacific Seed Association). (2004). Hybrid Rice Development in Asia: Assessment of Limitations and Potential. Proceedings of the

Regional Expert Consultation on "Hybrid Rice Development in Asia: Assessment of Limitations and Potential", 2 – 3 July 2014, Bangkok, Thailand. p 8

He, G.T., Zhu, X., Gu, H.Z. and Flinn, J.C. (1988). The use of hybrid rice technology: an economic evaluation. In: *Hybrid rice. Manila (Philippines): International Rice Research Institute* 229 – 241

He, G.T., Zhu, X. and Flinn, J.C. (1987). Hybrid seed production in Jiangsu Province, China. Oryza 24: 297 – 312

Indra, K. and Muhammad, D.B. (2019). Expanding Hybrid Rice Production in Indonesia. Center for Indonesian Policy Studies (CIPS). Jakarta, Indonesia

Khan, S.A.B.M.N., Baten, M.A. and Ramli, R. (2016). Technical, allocative, cost, profit and scale efficiencies in Kedah, Malaysia rice production: A Data Envelopment Analysis. *ARPN Journal of Agricultural and Biological Science*, 11(8), 322 – 335

Khushik, A.M., Lashari, M.I. and Memon, A. (2011). Performance of rice hybrid and other varieties in Sindh and Balochistan. *J. Agric. Res*, 49(4), 561 – 570

Li, J., Xin, Y. and Yuan, L. (2009). Hybrid rice technology development: ensuring China's food security. *IFPRI Discussion Paper 00918*. Washington, DC: International Food Policy Research Institute. p 15.

Mailena, L., Mad, N. S., Alias, R. and Latief, I. (2014). Rice farms efficiency and factors affecting the efficiency in MADA Malaysia. *Journal of Applied Sciences*, 14(18): 2177 – 2182

Mao, C.X., Virmani, S.S. and Kumar, I. (1998). Technological innovations to lower the cost of hybrid rice seed production. *Advances in hybrid rice technology*. International Rice Research Institute (IRRI), Manila, 111 – 128

Ni, D., Song, F., Ni, J., Zhang, A., Wang, C., Zhao, K., Yang, Y., Wei, P., Yang, J. and Li, L. (2015). Marker-assisted selection of two-line hybrid rice for disease resistance to rice blast and bacterial blight. *Field Crops Research*, 184: 1 – 8

Parichatnon, S., Maichum, K. and Peng, K.C. (2017). Evaluating technical efficiency of rice production by using a modified three-stage data envelopment analysis approach: A case study in Thailand. *International Journal of Scientific and Technology Research* 6(1): 152 – 159

Rahim, H., Ariff, E.E.E., Sobri, A.A., Amirul, M. and Wahab, M.A. (2019). The assessment of input factors and technical efficiency of rice in IADA Seberang Perak, Kerian and Barat Laut Selangor. *Economic and Technology Management Review,* Vol. 14: 13 – 22

Rahim, H., Ariff, E.E.E., Sobri, A.A., Amirul, M. and Wahab, M.A. (2020). The assessment of input factors and technical efficiency of rice production at Integrated Agriculture Development Authority (IADA) Pekan and Rompin. *Economic and Technology Management Review,* Vol. 15: 23 – 35

Serin, T., Ariff, E.E.E., Ali, R., Halim, N.A., Zakaria, M.H., Rahim, H. and Harun, R. (2019). Food security and sustainability: Malaysia agenda. *Malaysian Applied Biology*, 48(3): 1 – 9

Singh, H.P., Kujur, M.J. and Kalia, S. (2018). Hybrid Rice: Development, Constraints and Prospects–A review. *Bull. Env. Pharmacol. Life Sci*., Vol 7 [12] November 2018: 01 – 05

Venkatesh, V. and Davis, F.D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 46(2): 186 – 204.

Virmani, S.S., Mao, C.X., Toledo, R.S., Hossain, M. and Janaiah, A. 2002. Hybrid rice seed production technology and its impact on seed industries and rural employment opportunities in Asia. International Rice Research Institute, Metro Manila, Philippines. p 10.

Virmani, S.S. (2003). Advances in hybrid rice research and development in the tropics. In: Virmani SS, Mao CX, Hardy B, editors. Hybrid rice for food security, poverty alleviation, and environmental protection. *Proceedings of the 4th International Symposium on Hybrid Rice*, 14-17 May 2002, Hanoi, Vietnam. Los Baños (Philip- pines): International Rice Research Institute. p 7 – 20

Xie, F. and Hardy, B. (2009). Accelerating hybrid rice development. Int. Rice Res. Inst..

Yuan, L.P. (2004). Hybrid rice for food security in the world, FAO Rice Conference. Rome, Italy. http://www.fao.org/rice2004/en/pdf/longping.pdf

Zulkifli, N.A.A.M., Suhaimee, S. and Awang, M.R. (2016). Economic production and technology needs of coffee: Comparison of coffee cherry and coffee bean. *Economic and Technology Management Review*, Vol.11a: 27 – 35

Abstrak
Inovasi terbaru padi hibrid yang dikenali sebagai KADARIA 1 telah dihasilkan dan prestasi hasil varieti ini telah dinilai di jelapang-jelapang terpilih di Semenanjung Malaysia. Walaupun teknologi varieti ini telah dikembangkan selama lebih daripada 30 tahun di negara lain, teknologi ini masih baru di Malaysia kerana 10 tahun kebelakangan ini baru diterokai. Varieti hibrid menyumbang kepada peningkatan dalam prestasi hasil padi, oleh yang demikian banyak negara melabur secara intensif dalam mengembangkan pakej benih padi hibrid yang lebih maju untuk petani mereka. Perlu diperhatikan bahawa kos pengeluaran benih hibrid lebih tinggi jika dibandingkan dengan varieti inbred. Di samping itu, margin keuntungan yang tersekat kerana kecekapan teknikal yang rendah dan penurunan kembali ke skala keanjalan bagi sejumlah jelapang nasional serta kenaikan kos pengeluaran dalam penanaman padi memerlukan pertimbangan kritikal agar alternatif baru dapat diterokai. Oleh itu, kajian ini berusaha untuk menentukan potensi faedah sekiranya padi hibrid ini akan diguna pakai di jelapang-jelapang tersebut susulan varieti beras hibrid pertama berjaya dihasilkan iaitu KADARIA 1. Walau bagaimanapun, didapati bahawa usaha awal untuk menggunakan hibrid di jelapang agak sukar kerana prestasi hasil (7.32 tan/ha) yang tidak berbeza secara signifikan berbanding dengan inbred (6.23 tan/ha). Tambahan lagi, nisbah faedah kos (BCR) tidak menguntungkan sekiranya petani menggunakan KADARIA 1 untuk sawah mereka. Margin keuntungan menurun sebaik sahaja harga benih hibrid tidak disubsidi pada RM15.00/kg daripada anggaran asal harga komersial pada RM22.29/kg, yang menunjukkan perlunya kerajaan memberi subsidi benih apabila petani memilih untuk menanam hibrid. Walaupun prestasi hasilnya tidak signifikan seperti yang dinilai dalam kajian ini, penerokaan dalam pengembangan padi hibrid masih sangat penting memandangkan kemampuan varieti jenis ini yang lebih tahan terhadap perosak dan penyakit. Kajian mendapati bahawa penggunaan hibrid dalam penanaman padi dan pengeluaran benih berpotensi dilaksanakan ke jelapang hanya jika beberapa syarat dan peningkatan dapat dipenuhi. Ini dapat dilakukan sama ada melalui peningkatan prestasi hasil yang signifikan atau penghasilan benih hibrid secara ekonomi; atau kedua-duanya.