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Economic evaluation of partial mechanisation in young ginger production

(Penilaian ekonomi bagi mekanisasi separa dalam pengeluaran halia muda)

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Keywords: cultivation, efficiency, ginger, mechanisation package, partial budgeting

Abstract

Zingiber officinale Roscoe commonly known as ginger, is a rhizomatous plant belonging to the family Zingiberaceae. Native to India, this species is also considered indigenous to many regions across tropical Asia, from where it was subsequently introduced and cultivated in various parts of the world. Ginger is classified as an herbaceous plant and has been widely utilised, particularly in traditional medicine and Asian culinary traditions. Global ginger production shows an increase from 4.1 million mt (2017) to 5.5 million mt (2023). India, Nigeria and China have emerged as the leading global producers of ginger, collectively dominating approximately 66% of the world's ginger market as of 2023. In Malaysia, ginger production remains relatively low, with an output of approximately 10,785 mt recorded in 2023. Given that most ginger cultivation activities in Malaysia are still carried out manually, MARDI has developed a mechanisation package aimed at improving the efficiency of ginger production. This initiative seeks to alleviate the labour-intensive nature of ginger farming by introducing mechanised solutions that can reduce the physical workload on farmers and shorten the time required for various cultivation tasks. Partial Budgeting Analysis is used in analysing the ability to implement a business by expected returns as a result of changes in terms of technology adaptation or direct management. Overall, a partial budget analysis shows that the benefit or excessive value exceeds the implication if ginger cultivation is mechanised. The increase in machine rental costs can still be accommodated by the reduction of labour costs, with the recorded change value being positive. Considering the high price of mechanisation packages, the existence of service providers can help farmers through the rental of related machines. Intervention from the development agency is important to ensure that information related to this mechanisation package reaches users.

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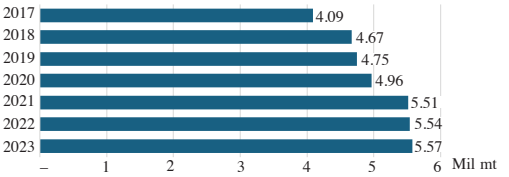
Introduction

Zingiber officinale Roscoe is a rhizome plant belonging to the Zingiberaceae family. The vernacular names for this plant are *halia* (Malay), *jahe* or *atuja* (Indonesian) and common ginger (English). The plant is native to India and is also a native plant in most areas of tropical Asia and was later introduced worldwide. This plant is a category of herbs that have high medicinal and commercial value (Park et al. 2002) and is widely used in traditional medicine, in addition to being widely used in Asian cuisine as a spice.

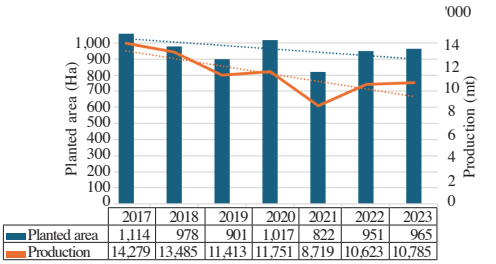
Global ginger production shows an increasing trend over the seven-year period, from 2017 – 2023. Data FAO (2024) indicated that global ginger production increased from 4.09 million mt (2017) to 5.57 million mt (2023). India is the world's leading producer of ginger and contributes about 40% of global production, while Nigeria and China become the top-producing countries after India.



(Source: FAO 2024)

Figure 1. Global ginger production, 2017 – 2023

Ginger is widely grown commercially in Bentong, Pahang; Keningau and Tambun in Sabah and Bakun in Sarawak. *Figure 2* indicates the ginger planted area (ha) and production (mt) trend in Malaysia from 2017 – 2023. Overall, both planted area and production exhibit a declining trend over the period. The planted area decreased from 1,114 ha in 2017 to 965 ha in 2023, while production dropped more significantly, from 14,279 mt in 2017 to 10,785 mt in 2023. The most pronounced reduction was observed in 2021, when production fell sharply to 8,719 mt, coinciding with the lowest planted area of 822 ha.



	2017	2018	2019	2020	2021	2022	2023
Planted area	1,114	978	901	1,017	822	951	965
Production	14,279	13,485	11,413	11,751	8,719	10,623	10,785

(Source: Agricultural Statistics, 2024)

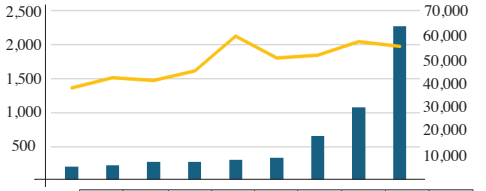
Figure 2. Malaysian ginger area and production, 2017 – 2023

Although there was some recovery in planted area in 2022 and 2023, production did not return to its earlier levels, indicating persistent challenges in the sector.

Bacterial issues in the soil and diseases such as Rhizome Rot are among the factors that make it difficult for Malaysia to achieve a high level of ginger production. Soil-borne pathogens can persist in the soil for extended periods, making them difficult to eradicate completely. Consequently, plot-based crop rotation must be implemented to restore soil fertility. The land should rest from ginger cultivation for a period of 3 – 5 years. During this fallow period, the planting of legumes is most suitable, as it effectively contributes to the restoration of soil fertility.

Data released by the Department of Statistics Malaysia (DOSM 2024), the Self-Sufficiency Rate (SSR) of ginger ranges from 14.6% – 18.9% over a 5 year period (2019 – 2023). The self-sufficiency ratio (SSR) reflects the extent to which domestic production can meet national demand for ginger and its relationship with trade patterns is clearly evident. A low SSR indicates that Malaysia is unable to satisfy local consumption through domestic output alone, thereby necessitating high import volumes to bridge the supply gap. At the same time, although ginger exports have grown in recent years, the absolute volume remains small relative to imports, highlighting Malaysia's continued dependence on external sources to ensure supply stability.

Based on Malaysia's ginger trade data from 2015 to 2023, the country remains highly dependent on imports despite notable growth in export volumes during the same period (*Figure 3*). Ginger imports have consistently been large and relatively stable, ranging from 38,072 mt in 2015 to a peak of 59,547 mt in 2019, with levels averaging above 50,000 mt annually after 2019. In contrast, exports started from a very low base of only 204 mt in 2015, but experienced rapid growth particularly after 2020, reaching 2,268 mt in 2023. While this sharp increase in exports reflects expanding opportunities in international markets, the figures are still minimal compared to the volume of imports. This wide disparity highlights the insufficient domestic production capacity to meet local demand and suggests that the cultivated area of ginger in Malaysia has declined over time, thereby reinforcing the nation's continued reliance on imported ginger.



	2015	2016	2017	2018	2019	2020	2021	2022	2023
Planted area	204	226	280	275	306	331	658	1,077	2,268
Production	38,072	42,435	41,232	45,261	59,547	50,612	51,754	57,156	55,354

(Source: FAO 2025)

Figure 3. Import and export of ginger in Malaysia, 2015 – 2023

Planting technology of young ginger

Cultivation is typically carried out on well-drained sandy loam or clay loam soils, often on slightly sloping land to avoid waterlogging. Nevertheless, the cultivation of ginger was conducted in accordance with the Standard Operating Procedures (SOP) established by MARDI, whereby planting was carried out on flat land and on raised beds under open-field conditions. The crop is propagated vegetatively using rhizome pieces, which are planted at the onset of the rainy season to ensure adequate soil moisture for sprouting. Farmers usually apply a combination of organic manure and chemical fertilisers (NPK) to maintain soil fertility and promote vigorous growth. Weed management is critical in the early stages, while pest and disease control, particularly against soft rot (caused by *Pythium* spp.) and rhizome fly infestation, is necessary to safeguard yields. The crop matures in about 4 – 5 months, after which the rhizomes are harvested, cleaned and marketed either fresh or processed (dried, powdered or pickled).

In Malaysia, ginger farming is mostly small-scale and labour-intensive. Still, there is growing interest in mechanisation and Good Agricultural Practices (GAP) to improve productivity, reduce costs and meet rising consumer demand for high-quality ginger.

Ginger farm mechanisation has become more popular worldwide due to the requirement for productivity and efficiency in the growing and harvesting processes. To solve conventional farming issues, several innovations, such as smart farming technologies and specialised harvesting equipment. These developments open the door for sustainable farming methods by improving production and streamlining resource management.

A compact ginger planter with a chain and bucket metering mechanism has been made especially for mountainous areas. It is lightweight and portable. Compared to manual techniques, this planter's 0.75 km/h speed greatly increases planting efficiency. (Patel et al. 2021). Another study created a seed metering mechanism that uses several seed sizes and a vertical rotating disc. At ideal speeds, the system achieved a Quality of Feed Index (QFI) of 77.14%, improving seed distribution and minimising damage. (Himanshu & Sawant 2023)

For effective harvesting, a diesel-powered device that makes use of a ploughshare has been created. When compared to manual methods, this machine greatly increases harvesting efficiency, enabling faster and more efficient ginger extraction (Luosheng 2019).

Digging, soil-beating and picking harvesters are examples of innovations that have been created to increase efficiency. These devices greatly cut down on harvesting time by using a tractor-driven system to dig, clean and gather ginger with little manual labour (Guo & Guo 2014). Affordability and suitability for regional farming methods are the main goals of localised solutions, such as the ginger harvesting equipment made for Indian circumstances. This tool has a screener and digger to reduce ginger damage (Sanjay et al. 2015).

Mechanisation in agriculture is not only achieved through ownership but also through rental from a service provider. Mechanisation rental in agriculture is a common practice that allows farmers to use modern agricultural equipment without purchasing the machinery outright. This is particularly beneficial for small- and medium-scale farmers who may lack sufficient capital. The high cost of mechanisation often serves as a constraint for these farmers in improving their return on investment. Several studies have indicated that most smallholder farmers in developing countries hire tractors or machinery services from service providers, which is a more viable (Diao et al. 2014; Benin 2015; Takeshima et al. 2015a). Labour shortages in agricultural areas have further created opportunities for mechanisation, which is often facilitated by such service providers, contributing to the sustained viability of smallholder farming (Takeshima 2017).

Rental-based mechanisation has been shown to yield a higher return on investment compared to outright purchase. The objective of this study is to evaluate the financial impact of a minor change in young ginger production. It aims to compare the costs and economic benefits of using mechanised production methods of young ginger by applying a technology package developed by MARDI. Young ginger was selected for analysis due to its shorter cultivation cycle, which allows for a faster return on investment. A total of five types of machines were developed and assembled by MARDI. The study assumes rental costs for each machinery and the time required for specific activities under both conventional and mechanised methods to determine the pricing system. Mechanisation through rental is expected to decrease operational costs by reducing dependency on labour, and allowing for more efficient use of agricultural inputs.

Comparison of mechanised and conventional young ginger cultivation

Young ginger has the potential to produce up to 10 mt/ha, but most farmers can produce between 9 – 10 mt/ha. Ginger cultivation in Malaysia has traditionally been practiced using conventional agricultural methods on mountain slopes. It requires intensive labour for the main operations such as land preparation, planting, crop management and harvesting as the production faces the risk of increased labour costs. Therefore, MARDI has developed a mechanisation package to help the small and medium scale farmers decreasing operational costs by reducing labour dependency and making farm operations less time-consuming. *Table 1* shows the list of machines in the mechanisation package that has been developed.

Crop management of ginger is accomplished through a series of six integrated mechanised operations that collectively address the critical stages of production, from the farm development to post-harvest handling. The process commences with the utilisation of a planting machine, which ensures precise placement of ginger rhizome at uniform depth and spacing, thereby promoting optimal crop establishment and early growth. Following establishment, soil fertility is enhanced through the application of organic inputs using an organic manure spreader, which distributes organic fertiliser at a calibrated rate to improve soil structure and nutrient availability. During the crop's vegetative

phase, the inter-row cultivator equipped with a fertiliser applicator performs dual functions by suppressing weed competition and simultaneously applying NPK fertiliser, thus maintaining field hygiene while supporting plant nutrition. Pest and disease pressures, which represent significant threats to yield stability, are managed through the deployment of a boom sprayer, enabling uniform application of pesticides and reducing the incidence of biotic stress. In the later stage of the production cycle, a leaf harvester facilitates the selective collection of ginger leaves, providing value-added products without causing damage to the rhizomes in situ. The final stage of the management system involves the use of a harvesting machine, which efficiently uproots mature ginger rhizomes and transports them to collection centres, thereby reducing post-harvest losses and labour dependency. Collectively, these six mechanised operations form a comprehensive crop management strategy that enhances efficiency, minimises production risks and supports sustainable intensification of ginger cultivation.

This table compares the activities involved in ginger cultivation using conventional versus mechanised methods, measured in man-hours/ha. It is divided into four main activities which are land preparation, planting, crop management and harvesting. For land preparation, both ploughing and rotor with bed making are already mechanised, requiring similarly around 3 – 4 man-hours, but mechanisation significantly reduces labour in manure spreading to 11.4 compared to 36 man-hours. During planting, mechanisation cuts down labour needs drastically, from 64 – 13 man-hours. In crop management, conventional practices such as spraying, fertilising and weed control are highly labor-intensive, up to 160 man-hours in total, whereas mechanised methods greatly reduce this burden, especially fertilising and weed control, from 80 – 6 man-hours. Harvesting also shows major time savings, with leaf harvesting (50 vs. 7.1) and ginger harvesting (83 vs. 2.5). Overall, the conventional method requires 399.7 man-hours/ha, while mechanisation reduces this to just 47.47 man-hours, highlighting the substantial efficiency gains from adopting mechanised practices.

Methodology

Data collection

The economic assessment was carried out using financial viability analysis and partial budgeting involving several cost estimates such as service capacity, capital cost, operating cost and service cost. Primary data obtained through face-to-face meetings with three farmers were used for this financial analysis. The farmers are currently cultivating young ginger conventionally with an average planting area of 1 ha. However, MARDI has given trials of mechanised young ginger cultivation for three seasons to obtain input and cost information.

Table 1. List of machines in the mechanisation package

Type of machine	Use
Planting machine	Planting ginger rhizomes
Organic manure spreader	Spreading an organic fertiliser on a plant-bed at specific rate
Inter-row cultivator with fertiliser applicator	Control weeds and spread NPK fertiliser
Boom sprayer	Spraying pesticides to control pests and diseases
Leaf harvester	Harvesting ginger leaf (pre-harvest)
Harvesting machine	Harvesting ginger and transporting the harvest from the farm to the collecting centre

Table 2. Comparison of activities between conventional and mechanised method

Activity	Type of machine	Sub activity	Man-hour/ha	
			Conventional	Mechanised
Land preparation		Ploughing	3 (Mechanised)	3
		Rotoring + bed making	3.7 (Mechanised)	3.7
	Organic manure spreader	Manure spreading	36	11.4
Planting	Planting machine	-	64	13
Crop management	Boom sprayer	Pest and disease control (spraying)	40	0.77
	Inter row cultivator with fertiliser applicator	Fertilising + weed control	80	6
		Weed control	40	
Harvesting	Leaf harvester	Leaf harvesting	50	7.1
	Harvesting machine	Ginger harvesting	83	2.5
		-	399.7	47.47

Partial budgeting analysis

In analysing the ability to implement a farm business, partial budgeting is usually used to determine expected returns as a result of changes in terms of technology adaptation or direct management. Partial budgeting is a tool used to assess the costs and benefits associated with a specific change in a farm (Soh 2014). Partial budgeting is very useful in making such changes in a farm (Alimi & Alofe 1992).

This partial budget analysis was developed involving four sections which are added income, reduced cost, added cost and reduced income. The basic principles of partial budgeting include focusing only on the changes in income flows or expenses such as added income, reduced costs, reduced income and increased costs (Kay et al. 2011). This situation is caused by several factors, such as the adoption of new technology, changes in project management, an increase in the workforce, changes in the project operation period, etc. The results of this analysis are as a guide to the viability of the project when the situation as stated occurs or needs to be adapted to one project.

Results

Young ginger cultivation in Malaysia requires approximately 4 – 5 months to reach harvest, depending on crop management practices and prevailing weather conditions. With a planting distance of 0.25 m × 0.50 m, the estimated plant density is 21,600 plants/ha, of which about 20,520 plants (95%) are expected to be productive. *Table 3* presents information on young ginger production under conventional and mechanised cultivation systems.

In the mechanised system, machinery is leased to farmers on a per-hectare, per-season basis, with the rental cost including wages, fuel and maintenance. The total yield obtained through conventional cultivation was 9,850 kg/ha/season, comparable to the yield achieved using mechanisation. The ex-farm selling price for each grade of young ginger ranges between RM4 and RM6/kg.

The capital cost of young ginger cultivation using conventional and mechanised methods amounts to RM2,457/ha/season. This includes land preparation, drainage, access roads, fencing, fertigation systems and basic planting materials. The capital cost is similar between the two methods, as both rely on the same machinery for land preparation.

Table 3. Information on young ginger production conventionally and using mechanisation (1 ha)

Item	Conventional and mechanisation
Planting distance	0.25 m x 0.5 m
Plant density/ha (plant)	21,600
Plant productive/ha (plant)	20,520
Average estimated weight/clump (kg)	0.6
Average production/ha/season (kg)	9,850
Post harvest losses	5%
Price/kg (RM)	6

However, differences arise in operating costs, where the total operating cost under the mechanised method is lower at RM38,569/ha/season, compared to RM41,473/ha/season under the conventional method. This 7% reduction in operating cost is primarily attributed to a 92% decrease in labour costs (from RM4,950 – RM400). Labour requirements under the mechanised method are limited to rhizome preparation activities, whereas in the conventional method, labour is required for nearly all cultivation activities, ranging from rhizomes preparation to harvesting. Wages are paid on a daily basis, at a rate of RM50/worker/day. The total wage cost therefore depends on the number of workers employed and the number of days required to complete each activity.

Although machine rental costs increased from RM450 – RM2,430 under mechanisation, this rise was relatively minor compared to the substantial savings in labour costs. Rental rates were determined based on the prevailing market average, ranging from RM250 – RM450, depending on the number of operators required and the duration of operation. At present, machine rental costs in the conventional method are incurred only for land preparation activities. The conversion to this mechanisation method has reduced the production cost for each kg by RM4.17/kg compared to RM4.46/kg. *Table 4* shows the difference in financial indicators for young ginger cultivation using conventional and mechanised methods by using projected cash flow analysis for 10 years. The net present value (NPV) for production using the conventional method is RM173,970 with an internal return rate (IRR) of 119% and a benefit cost ratio (BCR) of 1.4. The ROI is estimated at 93% starting in the first year. The NPV value for cultivation using mechanisation is higher at RM200,311. The IRR shows 136% with a BCR of 1.5. There is no significant difference for ROI where the value using this method is 97% starting the first year. A very high IRR value indicates that investment in young ginger production is highly profitable, with capital recovery occurring within a short period of 4 – 5 months and planting cycles between once or twice a year. This accelerates cash flow cycles and substantially increases the annual rate of return. In addition, production costs are relatively low, particularly when mechanisation is applied to reduce dependence on labour, while the market price of young ginger remains competitive and stable. The profit margin per hectare is considerably high relative to the inputs incurred, leading cash flow analysis to generate an exceptionally high internal rate of return. Furthermore, the inherent sensitivity of IRR to the ratio of costs and returns over a short production period further contributes to the seemingly large value. Therefore, the high IRR reflects that young ginger production is highly competitive, allows for rapid capital recovery and generates substantial profits within a short production cycle.

Table 4. Information on young ginger production financial (1 ha)

Item	Conventional (RM ha/season)	Mechanisation (RM ha/season)	Note
Gross income	59,098	59,098	
Capital cost	2,457	2,457	
Operation cost	41,473	38,903	
Net margin	15,168	18,072	
Production cost/kg	4.46	4.17	
NPV (RM)	173,970	200,311	A positive value (more than 0) indicates that the project has a very good cash flow throughout the project.
Internal Rate of Return (IRR)	119%	136%	The closer it gets to 100%, the better the project's return on investment is.
Benefit Cost Ratio (BCR)	1.4	1.5	It is based on an investment of RM1. If the value is more than 1, this project has a return on investment. The greater the value, the better the project.
Return on Investment (ROI)	93% (first year)	97% (first year)	The value over 10% indicates that the project can give a return on investment, considering the current value of money. The project is viable.
Payback period (Year)	1.07	1.99	A shorter payback period is better.

Table 5. Impact of conventional and mechanised young ginger production

Benefit		Implication	
A) Added income	RM/ha/season	A) Added cost	RM/ha/season
Income	0	Increased machinery rental costs	1,980
Sub total	0	Sub total	1,980
B) Reduced cost	RM/ha/season	B) Reduced income	RM/ha/season
Reduction of labour costs	4,550	None	
Sub total	4,550		
Total benefit	4,550	Total cost	1,980
Net benefit	2,570	per ha/season	

Table 5 presents the cost-benefit implications of conventional and mechanised young ginger production per-hectare per-season basis. The analysis shows that mechanisation does not contribute to additional income generation; however, its primary advantage lies in reducing production costs, particularly labour expenses. The reduction in labour costs is valued at RM4,550/ha/season, representing the main source of financial benefit.

Conversely, adopting mechanised practices incur added costs, particularly through machinery rental, which amounts to RM1,980/ha/season. The increase in machine rental costs can still be accommodated by reducing labour costs with the recorded change value being positive. The benefit value is about RM2,570/ha/season, which exceeds the

implication value. This result demonstrates that, mechanisation remains economically favourable as it offsets labour dependency and enhances overall production efficiency.

Conclusion and recommendation

A financial analysis comparing conventional practices and a mechanisation package through machinery rental in young ginger production revealed a net benefit difference of RM2,570/ha/season in favor of the mechanised approach. It is indicated that the increase about 13% farmers' income for every ha of young ginger production. This clearly demonstrates that mechanisation is not only a viable and practical alternative but also a worthwhile investment for farmers, as it lowers production costs significantly compared to conventional methods. The main source of cost advantage stems from substantial reductions in labor expenses. While machinery rental costs are slightly higher, the increment is minimal and more than compensated by the additional benefit of RM2,570/ha/season, which directly improves farmers' profitability and strengthens the economic justification for adopting mechanisation.

Overall, the adoption of mechanisation packages can significantly reduce the time farmers spend in the field. However, the high development and acquisition costs of such packages present a major barrier, particularly for small and medium scale farmers. To address this issue, a service-provider model is recommended, whereby machinery is made available to farmers on a rental basis. This approach is justified given the substantial capital investment required (estimated at RM420,600 for a complete machinery package), which is often beyond the reach of individual farmers due to their limited production scale. Through rental services, farmers are able to access the necessary machinery at affordable rates. Moreover, rental costs can be further reduced through economies of scale, as increased utilisation across larger cultivated areas (measured in hectares) leads to lower unit rental fees. In addition, certain machines have cross-commodity applications and are not restricted solely to ginger cultivation. This broadens the potential opportunities for rental services, thereby enhancing the overall viability of mechanisation adoption.

To realise the full potential of this approach, government intervention is essential. Support from relevant agencies (across research, development and marketing sectors) is needed to facilitate implementation. Additionally, governmental financial support in the form of loans, grants and incentives for service providers is crucial to catalyse the widespread availability of complete mechanisation packages. Qualified and capable farmers may also be empowered to become service providers themselves, offering mechanisation services to less-resourced peers. This not only promotes broader access to mechanisation but also enhances the income of service providers, thereby contributing to the overall stability and growth of the local economy.

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Abstrak

Zingiber officinale Roscoe yang lebih dikenali sebagai halia ialah tumbuhan berakar rizom daripada keluarga Zingiberaceae. Berasal dari India, spesies ini turut dianggap sebagai tumbuhan asli di banyak kawasan tropika Asia sebelum diperkenalkan dan diusahakan secara meluas di pelbagai negara di seluruh dunia. Halia diklasifikasikan sebagai tumbuhan herba dan telah digunakan secara meluas, terutamanya dalam perubatan tradisional dan masakan Asia. Pengeluaran halia dunia menunjukkan peningkatan daripada 4.1 juta mt (2017) kepada 5.5 juta mt (2023). India, Nigeria dan China muncul sebagai pengeluar utama global yang secara kolektif menguasai kira-kira 66% pasaran halia dunia pada tahun 2023. Di Malaysia, pengeluaran halia masih rendah dengan jumlah pengeluaran sekitar 10,785 mt pada tahun 2023. Memandangkan kebanyakan aktiviti penanaman halia di Malaysia masih dijalankan secara manual, MARDI telah membangunkan pakej mekanisasi bagi meningkatkan kecekapan pengeluaran halia. Inisiatif ini bertujuan mengurangkan sifat intensif buruh dalam penanaman halia dengan memperkenalkan penyelesaian berasaskan mekanisasi yang dapat meringankan beban fizikal petani serta memendekkan masa yang diperlukan untuk melaksanakan pelbagai tugas penanaman. Analisis Belanjawan Separa digunakan bagi menilai kebolehlaksanaan sesuatu perniagaan berdasarkan jangkaan pulangan hasil daripada perubahan yang melibatkan adaptasi teknologi atau pengurusan secara langsung. Secara keseluruhan, hasil analisis belanjawan separa menunjukkan bahawa faedah atau nilai lebihan yang diperoleh adalah melebihi implikasi kos sekiranya mekanisasi dilaksanakan dalam penanaman halia. Peningkatan kos sewaan mesin masih boleh ditampung oleh pengurangan kos buruh, dengan nilai perubahan yang direkodkan adalah positif. Memandangkan harga pakej mekanisasi adalah tinggi, kewujudan penyedia perkhidmatan dapat membantu petani melalui kemudahan sewaan mesin yang berkaitan. Campur tangan daripada agensi pembangunan adalah penting bagi memastikan maklumat berkaitan pakej mekanisasi ini dapat disampaikan kepada pengguna.