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RISK MITIGATION OF GREEN LETTUCE PRODUCTION (*Lactuca Sativa L.)* AT T.G.F CO., LTD, NAGASAKI, JAPAN

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ABSTRACT

This research aims to: (1) Identify risk events and causes; (2) Knowing the level of risk; (3) Mapping risks; and (4) Recommend preventive strategies that can be implemented in controlling appropriate risks in the green lettuce production process at T.G.F Co., Ltd. Data analysis was carried out using the HOR phase 1, Pareto diagram and HOR phase 2 methods. The data used were primary data and secondary data collected through observation, interviews, filling out questionnaires, and literature study. The resource persons in this research were the head of production, deputy field leaders, and permanent employees of T.G.F Co., Ltd. The results of this research show that there are 18 risk events and 22 risk causes in the entire green lettuce production process at T.G.F Co., Ltd. Analysis of the phase 1 HOR model and risk mapping using the Pareto diagram, it is known that there are 9 priority risk causes (2 in sowing, 1 in planting, 4 in maintenance, and 2 in harvesting). To deal with the causes of these priority risks, 19 preventive actions or mitigation strategies were formulated in the green lettuce production process at T.G.F Co., Ltd.

Keywords: *risk mitigation strategy; fishbone diagram; HOR mode; pareto diagram*

ABSTRAK

Penelitian ini bertujuan untuk: (1) Mengidentifikasi kejadian dan penyebab risiko; (2) Mengetahui tingkat risiko; (3) Memetakan risiko; dan (4) Merekomendasikan strategi preventif yang dapat diterapkan dalam mengendalikan risiko yang tepat pada proses produksi selada hijau di T.G.F Co., Ltd. Analisis data dilakukan menggunakan metode HOR fase 1, Diagram Pareto, dan HOR fase 2. Data yang digunakan berupa data primer dan data sekunder yang dikumpulkan melalui observasi, wawancara, pengisian kuesioner, dan studi pustaka. Narasumber pada penelitian ini adalah kepala produksi, wakil pemimpin lapangan, dan karyawan tetap T.G.F Co., Ltd. Hasil dari penelitian ini diketahui bahwa terdapat 18 kejadian risiko dan 22 penyebab risiko pada seluruh proses produksi selada hijau di T.G.F Co., Ltd. Berdasarkan hasil analisis model HOR fase 1 dan pemetaan risiko menggunakan diagram pareto, diketahui terdapat 9 penyebab risiko prioritas (2 pada penyemaian, 1 pada penanaman, 4 pada pemeliharaan, dan 2 pada pemanenan). Untuk menghadapi penyebab risiko prioritas tersebut, dirumuskan 19 aksi preventif atau strategi mitigasi pada proses produksi selada hijau di T.G.F Co., Ltd.

Kata Kunci: strategi mitigasi risiko; diagram fishbone; metode HOR; diagram pareto

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the horticultural commodities that has quite good prospects and commercial value. In Japan, lettuce is a popular vegetable that is usually served as an additional meal menu by the people. Its high demand also makes this lettuce cultivation have quite promising market opportunities, seen in terms of affordable prices and the need for lettuce that has high nutritional content. This is supported by data from *Japan Government Statics* (2022) regarding the graph of lettuce production data in Nagasaki from 2013-2022. The data shows that lettuce production in Nagasaki increased by 24.6% from 2013 to 2022, and the area also increased by 11.1%. This indicates that the demand for lettuce in Japan is also likely to increase.

One of the Japanese companies that produces lettuce is T.G.F Co., Ltd. This company is engaged in conventional vegetable cultivation, which refers to the standard or traditional method of growing vegetables that relies on chemical fertilizers, pesticides, and herbicides to enhance plant growth, control pests, and manage weeds.

T.G.F Co., Ltd. has three vegetable products that are cultivated according to the season, namely green lettuce, red lettuce, and okra. This research focuses on lettuce commodities because T.G.F Co., Ltd, which is the research site, produces lettuce in winter, starting from September to March, which coincides with the time of the research. This is by Sakura's (2016) theory that green lettuce in Japan is more suitable for growing in a cool climate, spring and autumn are generally the best seasons for conventional cultivation. Of course, as a company engaged in the agricultural sector, T.G.F Co., Ltd has risks that it faces.

Table 1. Production data of green lettuce and red lettuce at T.G.F Co., Ltd October 2023 – March 2024

Month	Production Target (Box)		Estimated Product (Box)		ed Product (Box)		Marketable Product Results (Box)		Percentage of Wasted Products	
	Green Lettuce	Red Lettuce	Green Lettuce	Red Lettuce	Green Lettuce	Red Lettuce	Green Lettuce	Red Lettuce	Green Lettuce	Red Lettuce
Oct	5.000	3.000	5.500	3.700	135	95	5.365	3.605	2,45%	2,57%
Nov	17.000	10.000	18.000	12.000	1.487	580	16.513	11.420	8,26%	4,83%
Dec	17.000	11.000	18.500	12.000	3.094	900	15.406	11.100	16,72%	7,50%
Jan	16.000	8.000	17.500	8.500	4.238	1.100	13.262	7.400	24,22%	12,94%
Feb	12.000	7.000	13.000	8.000	4.814	1.800	8.186	6.200	37,03%	22,50%
Mar	10.000	5.000	12.500	5.500	5.222	1.545	7.278	3.955	41,78%	28,09%

Source: T.G.F Co., Ltd Cultivation Report Year 2023-2024, data processed

Based on production data of green lettuce and red lettuce at T.G.F Co., Ltd October 2023 – March 2024, it is known that the production of green lettuce for six months has fluctuated. Only in October did lettuce production meet the target, while from November 2023 to March 2024 lettuce production still did not meet the target. This is because the quality of lettuce does not meet the feasibility standards desired by companies and consumers so it cannot be sold. According to information from the head of production, the number of green lettuce production that has decreased in production is due to several obstacles that occur during cultivation activities such as erratic temperatures in winter and worker errors during the *quality control process*.

The company has tried to minimize obstacles. However, production still does not meet the target. This shows that the production risk management implemented by T.G.F Co., Ltd is still not optimal. Therefore, risk mitigation is needed by identifying risk events and causes, measuring risks, mapping risks, and formulating risk mitigation strategies to reduce risks that can harm the company's finances in the future.

METHOD

This study discusses the risks of green lettuce production at T.G.F Co., Ltd. The initial risk mitigation analysis begins by identifying the risks that are likely to occur. In this study, the researcher used the Fishbone Diagram to determine the variables and dimensions that can be risks in the green lettuce production process. Furthermore, risk measurements were carried out using the Likert Scale. After obtaining the ARPj value, mapping was carried out to determine the priority of possible risks that must be avoided. Thus, the results of the risk mitigation strategy analysis were obtained to minimize various possible risks that might arise.

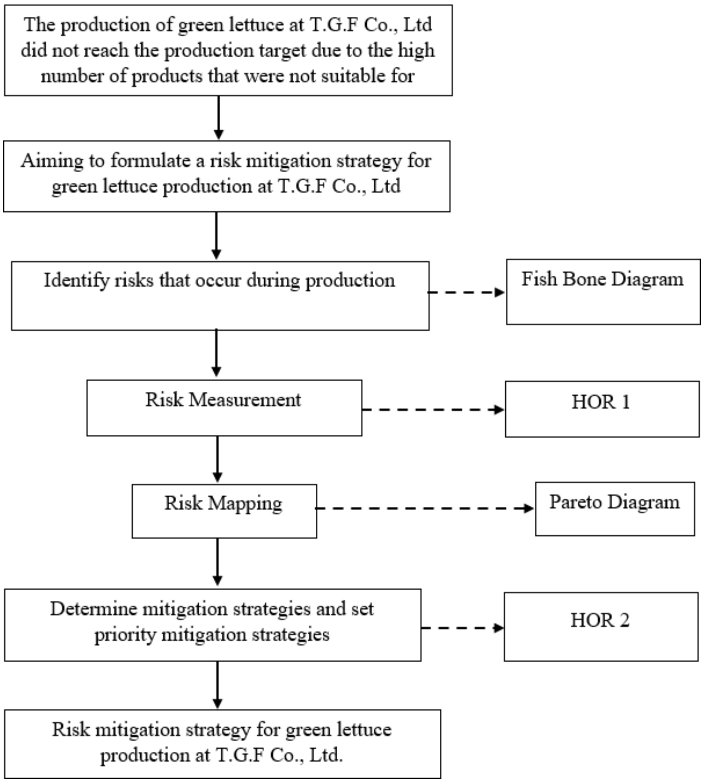

Figure 1. Framework Diagram

Location and Time of Research

This research was carried out at T.G.F Co., Ltd which is located in the reclaimed land of Oe, Isahaya, Nagasaki, Japan. The selection of the location of this research was carried out deliberately (*purposive*), with the consideration that T.G.F Co., Ltd is a company engaged in the agricultural sector with the main activity of lettuce cultivation. This research was conducted in October 2023 – March 2024.

Types and Data Sources

The types of data used in this study are primary data and secondary data. Primary data was obtained from observations, interviews, and filling out questionnaires by respondents. The respondents in this study consisted of three respondents, namely Yoshida *san* as the head of production, Ikeda *san* as the deputy field leader, and Furukawa *san* as the company's permanent employee. Meanwhile, secondary data was obtained from literature studies and literature that supported the theory as the basis for this study. The data collection method in this study is in the form of observations, interviews, filling out questionnaires by resource persons, and literature studies as relevant theoretical sources.

Method of Collecting Data

The data collection method in this study was in the form of direct observation by working and observing the cultivation process at T.G.F Co., Ltd., interviews with the head of production and employees, filling out questionnaires, and literature studies as a source of relevant theories.

Data Analysis

Data analysis is carried out through several stages, starting from the identification of risk events and causes, risk measurement, risk mapping, and the formulation of risk mitigation cause strategies.

Fish Bone Diagram

In risk identification, interviews and observations were conducted to analyze data using a fishbone diagram which aims to determine variables and dimensions that can be a risk to lettuce production at T.G.F Co., Ltd. According to Kurniasih (2020:20-25), fishbone diagrams are useful for analyzing and finding factors that have a significant influence or effect in determining the quality characteristics of work output. The creation of fishbone diagrams based on the type of classification of the production process in determining the problem is classified based on the production process or flow. Where, the incident in question is placed on the head of the fish, while the production processes are placed on the fishbone (Kuswandi & Mutiara, 2004; 81).

House of Risk (HOR)

House of Risk (HOR) is a methodology used to identify and manage risks in the supply chain. Pujawan & Geraldin (2009:956) explained that the implementation of HOR consists of two stages, namely HOR 1 is used to determine which sources of risk need to be prioritized in preventive actions. Meanwhile, HOR 2 gives priority to actions that are considered effective but with a reasonable commitment of funds and resources. Pujawan and Geraldin (2009:956

- 957) explained that adopting the HOQ procedure, HOR phase 1 was developed through the following stages:

1. Identify risk events that can occur in each business process. This can be done through supply chain mapping (*plan, source, make, deliver, and return*) and then identify what is lacking/wrong in each green lettuce production process at T.G.F Co., Ltd.
2. Estimate the impact (severity) of some risk events (if they occur). In this case, a scale of 1 - 5 is used where the number 5 indicates a severe impact. The severity of each risk event is placed in the right-hand column of the Table and is expressed as S. Originally, Pujawan, and Geraldin's (2009) theory used a scale of 1 – 10.

However, based on the modification theory used by the researcher, the measurements in this study use a scale of 1 – 5.

3. Identify the source of risk and assess the likelihood of each source of risk. In this case, a scale of 1 - 5 is set where 1 means rarely happens and a value of 5 means almost certainly happens. The source of risk (A_j) is placed in the top row of the Table and is associated with the bottom row event with the notation O_j.
4. Develop a matrix relationship, namely the relationship between each source of risk and each risk event, R_{ij} (0, 1, 3, 9) where 0 indicates no correlation and 1, 3, 9 indicates a low, medium, and high correlation respectively.
5. Calculate the aggregate *risk potential of agent j*=ARPj which is determined as a result of the possible events from the risk source j and the set of causal impacts of each risk event caused by the risk source j with the following formula:

$$\mathbf{ARPj = O_j \sum Si\ R_{ij}}$$

6. Rate risk sources based on the set of potential risks in descending order (from largest to lowest value).

Formulation of risk mitigation strategies using the HOR phase 2 method. Pujawan & Geraldin (2009:957-958) explain that HOR phase 2 steps are as follows:

1. Select several risk sources with high-priority ratings that may use the Pareto analysis of ARP_j, stated in the second HOR. The selection results will be placed on the left side (*what*) of HOR 2 listed in Table 4. Enter the appropriate ARP_j value in the right column
2. Identify relevant actions to prevent sources of risk. It should be noted that one source of risk can be addressed with more than one action and one action simultaneously can reduce the likelihood of the occurrence of more than one source of risk. The action is placed on the top row as '*How*' in HOR 2.
3. Determine the relationship between each preventive measure and each source of risk, E_{jk}. The value can be {0, 1, 3, 9} which shows

consecutive no correlation, low, medium, and high correlation between the action k and source j. This relationship (E_{jk}) can be considered as the degree of effectiveness of k actions in reducing the likelihood of a risk source event.

4. Calculate the total effectiveness of each action as follows:

$$\mathbf{TEk = \sum_j ARPj\ E_{jk}}$$

5. Assess the degree of difficulty in performing each action, D, and place those values in a row on the bottom row of total effectiveness. The level of difficulty indicated by the scale (such as the Likert scale or any other scale), should reflect the funds and other resources required to act.
6. Calculate the effective total on the difficulty ratio, i.e. $ETD_k = TE_k/Dk$.
7. Set a priority rating for each action ($_{R-k}$) where rank 1 gives the action meaning with the highest ETD_k.

Diagram Pareto

Risk mapping is analyzed using Pareto charts to find out the causes of risks that have the greatest impact on the company and are priority causes for mitigation. According to Sudarman (2021:1), the main purpose of the Pareto diagram is to identify and prioritize the most significant problems so that appropriate corrective actions can be taken.

RESULT AND DISCUSSION

Risk Identification

Identifying risks in the green lettuce production process at T.G.F Co., Ltd starts from the seeding, planting, maintenance, and harvesting processes. The following are the results of risk identification carried out using the fishbone diagram method (*fishbone*) listed in Figure 2.

In the body of the fish bone, the study has four variables, namely the lettuce production process at T.G.F Co., Ltd. Then, in each dimension becomes the place where the event or *Risk Event* (E_I).

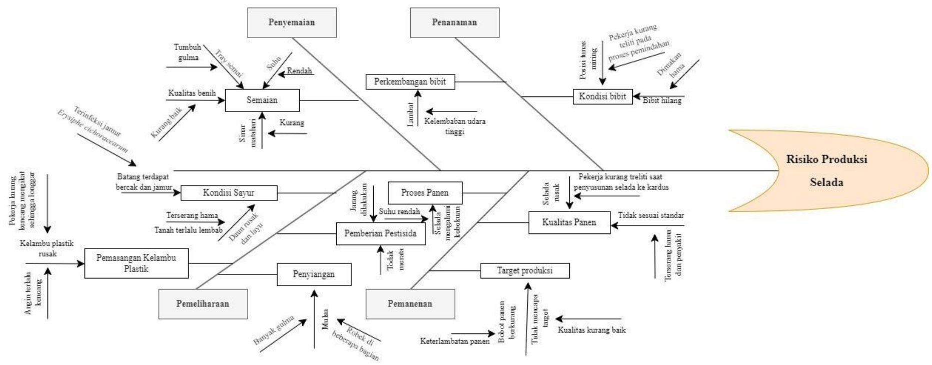

Figure 2. Fish Bone Diagram Classification of Green Lettuce Production at T.G.F Co., Ltd.

Furthermore, the results of risk identification from *the fishbone* diagram are described in a risk identification table, which contains the events and causes of risks in each green lettuce production process in T.G.F listed in Table 2.

Table 2. Occurrence and Causes of Risks in the Green Lettuce Production Process at T.G.F Co., Ltd.

Cultivation Process	Code	Risk Event (E_i)	Code	Risk *Agent* (A_j)
Seeding	E1	Seeds do not grow	A1	Poor seed quality
	E2	Seedlings become small	A2	Growing weeds on *seedling* trays
			A3	Lack of sunlight
			A4	Temperature too low
Planting	E3	Missing seedlings	A5	Seedlings are eaten by pests (birds and mice)
	E4	The position of the lettuce shoots is inclined	A6	Lack of thoroughness of workers during the seedling transplant process
	E5	The development of lettuce seedlings is slow	A7	High air humidity
Maintenance	E6	Lettuce stalks have spots and fungi	A8	Lettuce plants infected with the fungus *Erysiphe cichoracearum*
	E7	The edges of lettuce leaves are damaged (such as burning)	A9	Plants are attacked by pests (slugs, mice, birds)
	E8	Lettuce becomes wilted	A10	The soil is too moist
			A11	There are many weeds
	E9	Damaged plastic mosquito nets	A12	The wind is too strong
	E10	Collapsed plants	A13	Workers do not tie plastic mosquito nets tightly so that they are loose
	E11	Pesticides are unevenly distributed throughout the plant	A14	The use of pesticide concentrations is too high
	E12	The effectiveness of pesticides decreases	A15	The frequency of pesticide application is rare
	E13	There are weeds	A16	The mulch is torn in some parts
Harvesting	E14	Lettuce freezes	A17	Temperature too low
	E15	Crop yields do not meet company quality standards	A18	Lettuce plants are attacked by pests and diseases
	E16	Lettuce spoils when put in cardboard	A19	Workers are not careful when arranging lettuce into lettuce
	E17	Production does not reach the target	A20	The quality of lettuce is not good so it is not suitable for harvest
	E18	Reduced harvest weight	A21	Poor revocation process
			A22	Harvest delays due to bad weather

Based on Table 2, 18 risk events (Ei) were obtained, including 2 risk events in the seeding process, 3 risk events in the planting process, 8 risk events in the maintenance process, and 5 risk events in the harvesting process. Then, it was found that there were 22 causes of risk, including 4 causes of risk in the seeding process, 3 causes of risk in the planting process, 9 causes of risk in the maintenance process, and 6 causes of risk in the harvesting process.

Risk Level

The risk measurement of lettuce production at T.G.F Co., Ltd was carried out to determine the level of impact of risk events (S_i), the level of chance of the occurrence of risk causes (O_j), and the correlation between events and risk causes. The results of this measurement are then entered into the House of Risk (HOR) phase 1 table to calculate the Aggregate Risk Potential (ARP) value. The level of impact of a risk event on the production process of T.G.F Co., Ltd is measured using the *severity* value (Si) or a value that states how much impact or disruption is caused by a risk event to the company. The level of risk impact is assessed based on the Likert scale 1 – 5 with the criteria of

(1) non-significant impact value, (2) small impact value, (3) medium impact value, (4) large impact value, and (5) very large impact value. Meanwhile, the probability level of occurrence of risk causes is measured using the *occurrence* value (O_j). The occurrence value (O_j) is assessed based on the Likert scale of 1 – 5 with the criteria of (1) very rare occurrence value, (2) rare occurrence value, (3) medium occurrence value, (4) frequent occurrence value, (5) very frequent occurrence value. Then, the measurement of the level of correlation is seen from how much the relationship between a risk cause and the risk event is. Correlations that have a strong relationship are given a value of 9, correlations that have a medium relationship are given a value of 3, correlations that have a low relationship are given a value of 1, while correlations that have no relationship at all are given a

value of 0. The following are the results of the calculation of ARP values using the HOR phase 1 method.

Table 3. HOR Model Phase 1 Seeding Process

Risk Agent (A_j) / Risk Event (E_I)	1. Poor seed quality	Growing weeds on *seedling* trays	3. Lack of sunlight	Temperature too low	everity of Risk (Si)
Seeds do not grow	3	0	1	3	5
2. Seedlings become small	3	9	1	3	3,67
Occurrence of Agent j (O_j)	1,33	2	3,67	4,67	
Aggregate Risk Potential (ARP_j)	**34,59**	**66,06**	**31,82**	**121,47**	
Priority Rank	3	2	4	**1**	

The results of the *Aggregate Risk Potential* (ARP**)** calculation in the seeding process show that the risk causes that must be prioritized in strategic planning are too low temperatures and the growth of weeds on the *seedling* tray because it will have an impact on the risk of seeds not growing and seedlings becoming small. This is to the theory of Rubatzky & Yamaguchi (1998) that green lettuce grows optimally at temperatures between 15° and 25°C. Meanwhile, based on observations, in winter the temperature reaches 0°C which causes the seeds not to grow properly.

Table 4. HOR Model Phase 1 Planting Process

Risk Agent (A_j) / Risk Event (E_I)	Seedlings are eaten by pests (birds and mice)	Lack of thoroughness of workers during the seedling transplant process	7. High air humidity	Severity of Risk (Si)
3. Issuing seedlings	9	1	1	2,67
The position of the lettuce shoots is inclined	0	9	0	2,67
The development of lettuce seedlings is slow	3	0	3	4
Occurrence of Agent j (O_j)	4,67	2	4,67	
Aggregate Risk Potential (ARP_j)	**168,26**	**53,40**	**68,51**	
Priority Rank	**1**	3	2	

The results of the *Aggregate Risk Potential* (ARP**)** calculation in the planting process show that the risk that is prioritized in strategic planning is that it is eaten by pests (birds and rats) which will have an impact on the risk of seedling loss.

Table 5. HOR Model Phase 1 Maintenance Process

Risk Agent (A_j) / Risk Event (E_I)	Lettuce plants infected with the fungus *Erysiphe cichoracearum*	Plants are attacked by pests (slugs, mice, birds)	10. The soil is too moist	11. There are many weeds	12. The wind is too strong	13. Workers do not tie plastic mosquito nets tightly so that	The use of pesticide concentrations is too high	Frequency of pesticide application is rare	16. Mulch is torn in some parts	**Severity of Risk (Si)**
Lettuce stalks have spots and fungi	3	9	0	0	0	0	1	9	0	4,67

k Agent (A_j) / k Event (E_i)	Lettuce plants infected with the fungus *Erysiphe cichoracearum*	Plants are attacked by pests (slugs, mice, birds)	10. The soil is too moist	11. There are many weeds	12. The wind is too strong	13. Workers do not tie plastic mosquito nets tightly so that	he use of pesticide concentrations is too high	requency of pesticide application is rare	16. Mulch is torn in some parts	**Severity of Risk (Si)**
The edges of lettuce leaves are damaged (such as burning)	1	9	1	0	0	0	3	1	0	5
8. Lettuce becomes wilted	1	3	3	9	0	0	1	0	0	4,33
9. Damaged plastic mosquito nets	0	1	0	0	9	3	0	0	0	3,33
10. Collapsed plants	0	1	0	9	9	3	0	0	0	3,67
Pesticides are unevenly distributed throughout the plant	0	0	0	0	9	0	0	0	0	3,67
The effectiveness of pesticides decreases	3	0	0	0	3	0	3	9	0	4,67
13. There are weeds	0	0	9	9	0	0	1	1	9	4
Occurrence of Agent j (O_j)	4	3,67	3,33	4,67	3	3	2	4,67	3,33	
Aggregate Risk Potential (ARP_j)	**149,40**	**392,76**	**179,79**	**504,36**	**330**	**63**	**84,02**	**434,59**	**119,88**	
Priority Rank	6	3	5	**1**	4	9	8	2	7	

The results of the *Aggregate Risk Potential* (ARP**)** calculation in the maintenance process show that the risk causes that must be prioritized in strategic planning are that there are many weeds and the frequency of pesticide application is rare which will have an impact on the risk of lettuce wilting, plants collapsing, lettuce stalks with spots and fungi, and the effectiveness of pesticides decreases. This is supported based on the results of observations where there are a lot of weeds that are not handled until some cover the lettuce plants which causes the lettuce to wilt and be damaged.

Table 6. HOR Model Phase 1 Harvesting Process

k Agent (A_j) / k Event (EI)	17. Temperature too low	Lettuce plants are attacked by pests and diseases	Workers are not careful when arranging lettuce into lettuce	The quality of lettuce is not good so it is not suitable for harvest	21. Poor revocation process	Harvest delays due to bad weather	ty of Risk (Si)
14. Lettuce freezes	9	0	0	0	0	0	2
Crop yields do not meet company quality standards	9	9	9	9	0	1	4,33
Lettuce spoils when put in cardboard	0	0	9	1	0	0	3,33
17. Production does not reach the target	3	9	0	9	0	3	5
18. Reduced harvest weight	0	9	0	9	1	0	4
Occurrence of Agent j (O_j)	3	4,33	3	4	1	2	
Aggregate Risk Potential (ARP_j)	**215,91**	**519,47**	**206,82**	**493,2**	**4**	**38,66**	
Priority Rank	3	**1**	4	2	6	5	

The results of the *Aggregate Risk Potential* (ARP**)** calculation in the harvesting process show that the risk causes that must be prioritized in strategic planning are lettuce plants attacked by pests and diseases and the quality of lettuce is not good so it is not suitable for harvest, which has an impact on the occurrence of crop risk not by the company's quality standards, production results do not reach the target, and the harvest weight is reduced.

Risk Mapping

Risk mapping is carried out to find out what risk causes are prioritized for preventive or mitigation actions. After the ARP value is obtained, then risk mapping is carried out by making a Pareto diagram. By the principle of the Pareto diagram where the causes of risk that need to be prioritized are the cumulative percentage that has a value below 80%, while the percentage above 80% to 100% can be ignored. The following are the results of risk mapping using a Pareto chart.

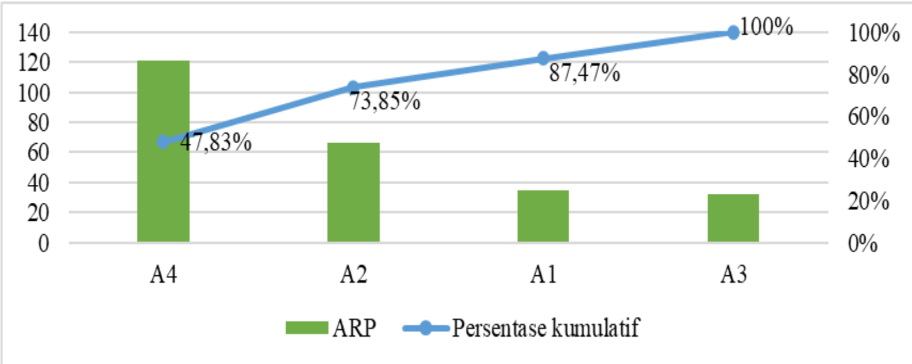

Figure 3. Pareto Diagram on the Seeding Process

In the seeding process, 2 risk causes have a cumulative percentage below 80% so it needs to be a priority for risk mitigation, namely the temperature is too low with a cumulative percentage of 47.83%, and the growth of weeds on the seedling tray with a cumulative percentage of 73.85%. This is in line with the explanation of Malhi et al (2021:6) that agriculture is the most vulnerable sector to climate change, owing to its huge size and sensitivity to weather parameters, thereby causing huge economic impacts. The changes in climatic events such as temperature and rainfall significantly affect the yield.

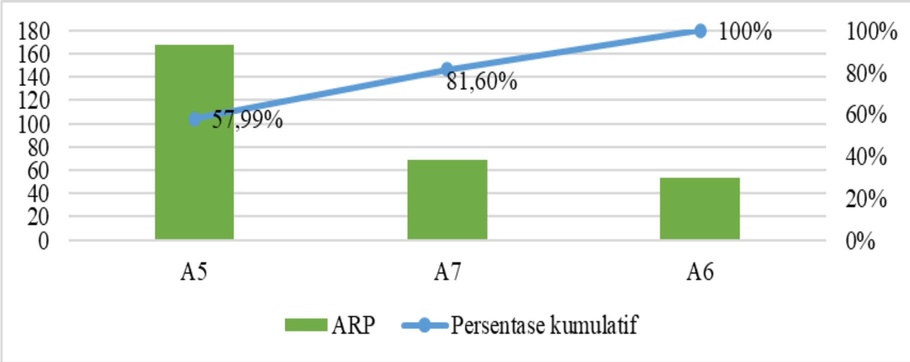

Figure 4. Pareto Diagram on the Planting Process

In the planting process, there is 1 risk that has a cumulative percentage below 80% so it needs to be a priority for risk mitigation, namely seeds are eaten by pests (birds and rats) with a cumulative percentage of 57.99%.

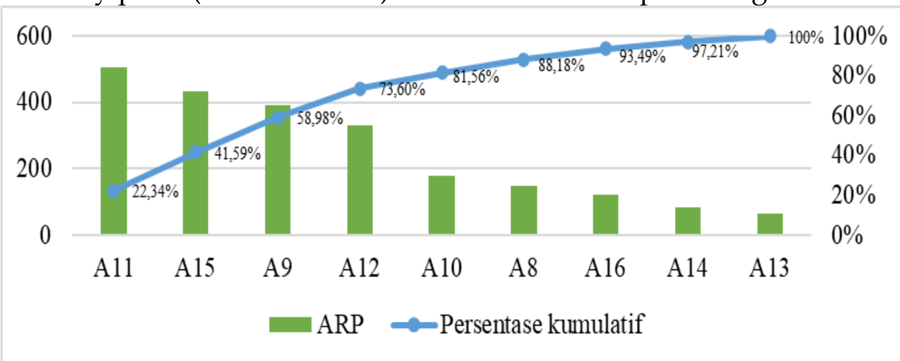

Figure 5. Pareto Diagram on the Maintenance Process

In the maintenance process, 4 risk causes have a cumulative percentage below 80% so it needs to be a priority for risk mitigation, namely, there are many weeds with a cumulative percentage of 22.34%, the frequency of pesticide application is rare with a cumulative percentage of 41.59%, plants are attacked by pests (snails, rats, birds) with a cumulative percentage of 58.98%, and the wind is too strong with a cumulative percentage of 73.6%.

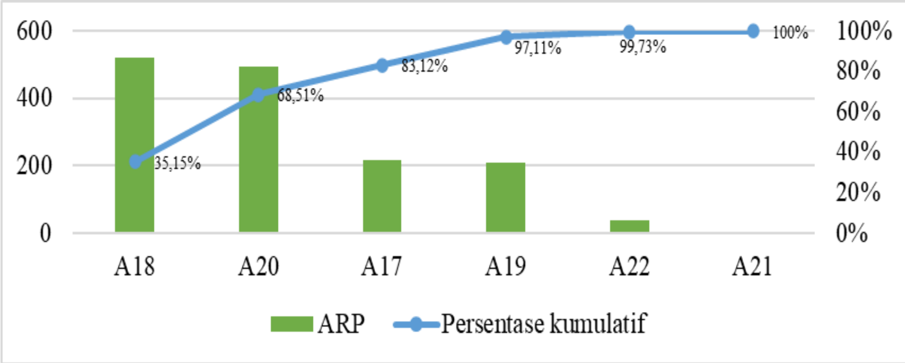

Figure 6. Pareto Diagram on the Harvesting Process

In the harvesting process, 2 risk causes have a cumulative percentage below 80% so that needs to be a priority for risk mitigation, namely lettuce plants are attacked by pests and diseases with a cumulative percentage of 35.15%, and the quality of lettuce is not good so that it is not suitable for harvest with a cumulative percentage of 68.51%. According to Malhi et al (2021:10), the change in climate or weather pattern of an area is predicted to increase a crop's susceptibility to various pests, diseases, and weeds.

Risk Mitigation Strategies

Risk mitigation strategies are identified to determine the appropriate handling in dealing with priority risk causes. This identification is carried out in each production process including seeding, planting, maintenance, and harvesting. In the identification of risk mitigation strategies, 3 strategies were obtained in the seeding process, 4 strategies in the planting process, 8 strategies in the maintenance process, and 4 strategies in the harvesting process.

Table 7. Risk Mitigation Strategy in the Green Lettuce Production Process at T.G.F Co., Ltd.

oduction Process	**Code**	**ority Risk Causes**	**Code**	**Mitigation Strategies**
Seeding	A4	Temperature too low	PA1	Using *a heating mat* in winter to stabilize the temperature of the *seedling* tray
			PA2	Install an alarm system in winter to monitor and provide early warning if the temperature drops below the optimal limit
	A2	Growing weeds on *seedling* trays	PA3	Conduct regular inspections and manual weeding more thoroughly to remove weeds that appear
Planting	A5	Seedlings are eaten by pests (birds and mice)	PA4	Using pest traps around plants
			PA5	Installing more ultrasonic repellents with owl visuals to repel pests
			PA6	Planting companion plants to repel pests around the lettuce area
			PA7	Covering the planting area with an anti-pest net
Maintenance	A11	There are many weeds	PA8	Perform manual weeding more regularly
			PA9	Using safe herbicides
	A15	The frequency of pesticide application is rare	PA10	Using drone technology to spray pesticides in winter
	A9	Plants are attacked by pests (slugs, mice, birds)	PA11	Using natural predators to control pests
			PA12	Establish a routine and regular pesticide application schedule
	A12	The wind is too strong	PA13	Carry out regular monitoring and maintenance of plant mosquito nets
			PA14	Providing training to part-time workers
			PA15	Utilizing *Solar Powered LoRaWAN* technology for effective land monitoring
Harvesting	A18	Lettuce plants are attacked by pests and diseases	PA16	Maximizing maintenance well during the growth process
	A20	The quality of lettuce is not good so it is not suitable for harvest	PA17	Using high-quality seeds
			PA18	Conducting post-harvest sorting
			PA19	Ensuring the right harvest time

Risk Mitigation Strategy Priorities

The prioritization of risk mitigation strategies is carried out to determine the most effective mitigation strategy recommendations for

T.G.F Co., Ltd. The results of the risk mitigation strategy priorities are obtained from the total effectiveness of the difficulty ratio (ETD_k) which is calculated by dividing the total effectiveness of each risk strategy (TE_k) by the level or degree of difficulty in implementing the risk mitigation strategy (Dk). After the calculation, *the ranking of* mitigation strategies is carried out based on the total value of the difficulty ratio effectiveness (ETD_k) from the largest to the smallest. The mitigation strategy with the highest ETD_k value is prioritized as the most effective risk mitigation strategy and is recommended to be implemented first. The following are the results of determining priority mitigation strategies using the HOR phase 2 method.

Table 8. HOR Model Phase 2 Seeding Process

***Preventive action* (PA)** / ***Risk Agent* (A_j)**	Using *a heating mat* in winter to stabilize the temperature of the *seedling* tray	Install an alarm system in winter to monitor and provide early warning if the temperature drops below the optimal limit	Conduct regular inspections and manual weeding more thoroughly to remove weeds that appear	**ARPj**
Temperature too low	9	3	0	121,47
Growing weeds on *seedling* trays	0	0	9	66,06
***Total Effectiveness* (TE_k)**	1093,23	364,41	594,54	
***Degree of Difficulty Performing Action* (Dk)**	3	4,33	3	
***Effectiveness of Difficulty Ratio* (ETD_k)**	364,41	84,16	198,18	
Rank	1	3	2	

The priority order of implementation of preventive actions (PA) or mitigation strategies for risk handling in the seeding process is as follows:

1. Using *a heating mat* in winter to stabilize the temperature of the *seedling* tray (PA1).
2. Perform regular inspections and manual weeding more thoroughly to remove emerging weeds (PA3).
3. Install an alarm system in winter to monitor and provide early warning if the temperature drops below the optimal limit (PA2).

Table 9. HOR Model Phase 2 Planting Process

***Preventive action* (PA)** / ***Risk Agent* (A_j)**	Using pest traps around plants	Installing more ultrasonic repellents with owl visuals to repel pests	Planting companion plants to repel pests around the lettuce area	Covering the planting area with an anti-pest net	**ARPj**
Seeds eaten by pests (birds and mice)	9	9	3	3	168,26
***Total Effectiveness* (TE_k)**	1514,34	1514,34	504,78	504,78	
***Degree of Difficulty Performing Action* (Dk)**	3,67	3,33	4,67	4	
***Effectiveness of Difficulty Ratio* (ETD_k)**	412,63	454,76	108,09	126,2	
Rank	2	1	4	3	

The priority order of implementation of preventive actions (PA) or mitigation strategies for risk management in the planting process is as follows:

1. Installing more ultrasonic repellents with owl visuals to repel pests (PA5).
2. Using pest traps around plants (PA4).
3. Cover the planting area with an anti-pest net (PA7).
4. Plant companion plants to repel pests around the lettuce area (PA6).

Table 10. HOR Model Phase 2 Maintenance Process

Preventive Action (PA) / *Risk Agent* (A_j)	Perform manual weeding more regularly	Using safe herbicides	Using drone technology to spray pesticides in winter	Using natural predators to control pests	Establish a routine and regular pesticide application schedule	Carry out regular monitoring and maintenance of plant mosquito nets	Providing training to part-time workers	Utilizing *Solar Powered LoRaWAN* technology for effective land monitoring	**ARPj**
There are many weeds	9	9	0	0	0	0	0	3	504,36
The frequency of pesticide application is rare	0	0	9	0	9	0	0	0	434,59
Plants are attacked by pests (slugs, mice, birds)	0	0	9	9	9	0	0	9	392,76
The wind is too strong	0	0	0	0	0	9	3	0	330
Total Effectiveness **(TE_k)**	4539,24	4539,24	7446,15	3534,84	7446,15	2970	990	5047,92	
Degree of Difficulty Performing Action **(Dk)**	3,33	3,33	4,33	5	4	3,67	3,67	4,33	
Effectiveness of Difficulty Ratio **(ETD_k)**	1363,14	1363,14	1719,67	706,97	1861,54	809,26	269,75	1165,8	
Rank	3	3	2	7	1	6	8	5	

The priority order of implementation of preventive actions (PA) or mitigation strategies for risk handling in the maintenance process is as follows:

1. Establish a routine and regular pesticide application schedule (PA12).
2. Using drone technology to spray pesticides in winter (PA10).
3. Perform manual weeding more routinely (PA8).
4. Uses a safe herbicide (PA9).
5. Utilizing Solar Powered LoRaWAN technology for effective land monitoring (PA15).
6. Carry out routine monitoring and maintenance of plant mosquito nets (PA13).

7. Using natural predators to control pests (PA11).
8. Providing training to part-time workers (PA14).

Table 11. HOR Model Phase 2 Harvesting Process

***Preventive Action* (PA)** / ***Risk Agent* (A_j)**	Maximizing maintenance well during the growth process	Using high-quality seeds	Conducting post-harvest sorting	Ensuring the right harvest time	**ARPj**
Lettuce plants are attacked by pests and diseases	9	9	0	0	519,47
The quality of lettuce is not good so it is not suitable for harvest	9	9	1	3	493,2
Total Effectiveness **(TE_k)**	9114,03	9114,03	493,2	1479,6	
Degree of Difficulty Performing Action **(Dk)**	3,67	4	4	3,67	
Effectiveness of Difficulty Ratio **(ETD_k)**	2483,39	2278,51	123,3	403,16	
Rank	1	2	4	3	

The priority order of implementation of preventive actions (PA) or mitigation strategies for risk management in the harvesting process is as follows:

A. Maximize maintenance well during the growth process (PA16).
B. Using high-quality seeds (PA17).
C. Ensuring the right harvest time (PA19).
D. Conducting post-harvest sorting (PA18).

CONCLUSION

Based on the results of data processing and analysis that has been carried out to answer the formulation of the problem, the conclusions obtained are:

1. The identification of risk events and risk agents was carried out in each green lettuce production process at T.G.F Co., Ltd, which included seeding, planting, maintenance, and harvesting, with the results of 18 risk events (2 in the seeding process, 3 in the planting process, 8 in the maintenance process, and 5 in the harvesting process) and 22 risk causes (4 in the seeding process, 3 in the planting process, 9 in the maintenance process, and 6 in the harvesting process).
2. Risk measurement in the green lettuce production process at T.G.F Co., Ltd was carried out using the HOR phase 1 model which produces an *Aggregate Risk Potential* (ARP) value from the largest to the smallest to determine the order of risk causes that must be prioritized. The risk causes with the highest ARP assessment in each production process are too low temperature (A4) in the seeding process, seeds eaten by pests (birds and rats) (A5) in the planting process, there are many weeds (A11) in the maintenance process, and plants are attacked by pests and diseases (A18) in the maintenance process.
3. Risk mapping is carried out to determine the causes of risk that are priorities for preventive or mitigation actions. The results of the risk mapping that occurred in the green lettuce production process at T.G.F Co., Ltd obtained a total of 9 risk causes that are prioritized (2 in the seeding process, 1 in the planting process, 4 in the maintenance process, and 2 in the harvesting process).
4. Based on the results of the identification of mitigation strategies and the calculation of HOR phase 2, 19 preventive actions (PA) or mitigation strategies were obtained in the entire green lettuce production process at T.G.F Co., Ltd.

SUGGESTION

Based on the results of the research that has been carried out, the suggestions that can be given are as follows:

1. T.G.F Co., Ltd needs to follow up on the causes of risks that occur in each production process, focusing on priority risk causes.
2. T.G.F Co., Ltd can implement the recommended risk mitigation strategies based on the results of research on priority risk mitigation strategies, namely:
   (1) Seeding process: Using *a heating mat* in winter to stabilize the temperature of the *seedling* tray.
   (2) Planting process: Installing more ultrasonic repellents with owl visuals to repel pests.
   (3) Maintenance process: Establish a routine and regular pesticide application schedule
   (4) Harvesting process: Maximizing maintenance well during the growth process.

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