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Risk identification of post-harvest losses at farm level: A case study of edamame in Indonesia

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Abstract

In Indonesia, the agroindustry, as a part of agribusiness, is a major component of national economic development. In agroindustry, processed edamame is a commodity that contributes substantially to employment and generating income. Currently, edamame is an agroindustrial product with high annual export opportunities to Japan and the USA. However, edamame has a high potential risk of post-harvest loss during supply chain activities. This study identified the post-harvest losses of edamame caused by field activities. Alternatives were investigated to reduce the potential risks of reduced edamame production. Direct survey and departmental interviews using questionnaires were implemented to obtain detailed data. Failure mode and effect analysis, risk priority number and the analytical hierarchy process were used to analyze the data collated for this study. The results indicated that plant pests and diseases (48.08), lack of worker skill in the picking process (38.60), competing wild plants (29.56) and use of pesticides (27.72) were the implicated critical risk factors associated with the post-harvest loss of edamame. Controlling pests and diseases (0.242) was the highest strategic priority to reduce post-harvest loss of edamame.

Introduction

Edamame grows well as a tropical vegetable in plantations in Indonesia, where there are suitable soils and climate (Purnama et al., 2018). Edamame is recognized as an industrial plant with a high potential for export because of its high economic value due to value-adding and the provision of job opportunities to increase farmer income (Nakano, 1991). As a cash crop with a short cycle, edamame can be cultivated four to six times a year under an irrigated cropping system and the yield of edamame can reach up to 10 t/ha of marketable fresh pods (Djanta et al., 2020). Edamame production increased from an average of 257 t in 1994–1998 to 3,510 t in 2010–2014, while in 2019, total exports reached 6,790.7 t (Ministry of Agriculture of the Republic of Indonesia, 2019). Relative to the export performance of the Japanese market, Indonesia still has negative comparative advantages compared to Taiwan and Thailand (Purnama et al., 2018). Therefore, quality improvement of the edamame product in Indonesia is required to support its export performance (Purnama et al., 2018).

A study reported that decreasing the production of edamame increased the cost per kilogram of the product (Cheng, 1991). In addition, relative to the skill of workers, the age of the labor force in the harvesting process of edamame is a crucial factor that affects harvesting activities (Nakano, 1991). Other factors were cultivars and origins of edamame, which determine the quality and appearance of the product and these factors may also affect the price and consumer preferences (Mimura et al., 2007).

Currently, postharvest loss in horticulture, especially in agricultural countries, has received increasing attention from the perspective of benefits to food and nutritional security, agroindustrial activities and the development of rural livelihoods (Kader et al.,

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2004; Parfitt et al., 2010; Hodges et al., 2011; Kitinoja et al., 2011; Kitinoja, 2013; Mohammed, 2014; Affognon et al., 2015). In terms of fruit and vegetable products, poor harvesting is among the reasons for postharvest losses, mainly attributed to during picking of the crop (Negi and Anand, 2016).

Hasbi (2012) reported that postharvest activities in agricultural products include the activities from harvesting to processing into end products. Postharvest handling has several purposes, including reduction of product losses, maintenance of product quality, extension of shelf life, diversification of agricultural commodities, creation of job opportunities and increment of value-added of products (Arah et al., 2016). The risk of post-harvest losses of agricultural products is potentially high during post-harvest activities. Post-harvest loss of edamame results in a decrease in the amount of harvested edamame from the picking process and during transportation from the field to the processing center. A good transportation process is needed when collecting products from farmers or fields in some agricultural areas (Rahmayanti et al., 2018).

High research interest in topics related edamame has been reported in Asia and America, especially regarding agronomic aspects of yield, yield components and quality (Basavaraja et al., 2005; Duppong and Hatterman-Valenti, 2005; Zhang and Kyei- Boahen, 2007; Kumar et al., 2011). Other researchers have used preference analysis and nutritional evaluation of edamame (Castoldi et al., 2011; Takahashi and Ohyama, 2011; Carson et al., 2011, 2012; Bhattacharya and Malleshi, 2012; Jadhav et al., 2018;) and storage of edamame has been investigated (Saldivar et al., 2010; Xu et al., 2012; Lara et al., 2019). However, little research has focused on the risk and causes of post-harvest loss of edamame. Post-harvest loss of edamame is caused by several factors, such as handling and the use of tools during product handling activities (Ismawari, 2012). The major causes of losses of emanate result from high temperatures during harvesting and rough post-harvest handling of fresh produce, while inadequate pest control management and nutrient supply during pre-harvest periods also contribute to the product losses (Munhuweyi et al., 2016). Djanta et al. (2020) explained the causes of postharvest loss of edamame at the field level in terms of production constraints, pests and diseases that were known to cause significant quality loss of edamame. Apart from pests and diseases, weeds were also reported as a major constraint in edamame production (Sharma and Kshattry, 2013).

In agroindustrial companies, the causes of postharvest loss are factors which have strong potential to reduce the yields of harvested products during a certain period of agricultural activity (Badariah et al., 2016). Recognizing risks or potential causes is required to avoid postharvest loss during product (as raw material) procurement activities (Fahmi, 2011).

In terms of risk management, a common method implemented in agroindustrial activities for identifying the source of risk is failure mode and effect analysis (FMEA). FMEA can be utilized to analyze and find the rate of values responsible for frequent failures (Salomon et al., 2015). FMEA is an effective analytical tool that is widely used to assess the importance of risks and to identify potential causes and effects (Giannakis and Papadopoulos, 2016). The FMEA concept has been applied to determine the severity level, event and detection level. FMEA can be applied in conjunction with risk priority number (RPN) to determine the level of risk of failure (Wessiani and Yoshio, 2018). The combined result of the RPN calculation for each potential failure indicates the risk, with a higher RPN score implying greater risk (Curkovic et al., 2013).

The development of postharvest loss management of edamame in Indonesia is heavily affected by uncertain potential risks, particularly at the farm level. This study aimed to identify the causes of postharvest losses and the sources of loss risk of harvested edamame at the farm level. Based on information generated from this study, recommendations could be proposed to companies to prevent product losses during postharvest activities at the farm level.

Materials and Methods

Location, data collection, and analysis

This study was conducted in a company field in the Jember District of East Java, Indonesia with a high quantity of export product of edamame. This study focused on a cultivated area (18 ha) with an average yield of 6 t/ha. The workers involved in this cultivation area were the field manager, field assistant manager, field staff and picking workers. In a certain period of time during the harvesting season, 100–150 workers/ha were involved in the field during the harvesting process. Direct visits, direct inspection and in-depth discussion with key persons or experts in the field were done to determine the field conditions. A questionnaire was addressed to key persons to obtain accurate information to support some of the analysis required in this study. One manager, three assistant managers, three field staff and six field workers (pickers and leader of picker group) were also invited as experts or key persons to discuss the collation of data and information related to the field area of this study. The educational background of the field manager and field assistant manager were to the level of a Bachelor's degree or a diploma in agricultural science, respectively. The field staff mostly had a diploma degree in agriculture. Most of the picking workers and field workers were graduates from senior high school or below and had agricultural work experience. This study focused on field activities (picking process, weighing, and transport to the processing unit). Fishbone analysis was implemented to investigate the causes of postharvest loss due to the picking process in the field and transportation to the processing unit. FMEA followed by RPN were used to identify the causes of overall failure and to determine the potential causes of failure (Rucitra, 2018).

FMEA is a method used for identifying and preventing product and process problems before they occur (Mc Dermott et al., 2009). In the FMEA process, there are three dimensions related to the relative risk of failure: severity (S) is the consequences of the failure; occurrence (O) is the probability or frequency of the failure occurring; and detection (D) is the probability of the failure being found before the effect has occurred.

In this study, based on the data and process of edamame business, potential failure mode and effect were rated on a scale of 1–5 (with 1 being the best and 5 being the worst case). Tables 1, 2 and 3 show the rating scale of occurrence, severity, and detection of risk, respectively.

Table 1 Occurrence rating scale (Silva et al., 2014)

Rating	Description	Potential failure rate
5	Failure is almost inevitable	Failure occurs predictably, or failure occurs every week
4	Very high probability of occurrence	Failure occurs approximately once per month
3	Moderate probability of occurrence	Failure occurs occasionally or failure occurs once every 3 months or every season
2	Low probability of occurrence	Failure occurs rarely, or failure occurs about once per year
1	Remote probability of occurrence	Failure almost never occurs; no one remembers the last failure

Table 2 Severity rating scale (Silva et al., 2014)

Rating	Description	Definition
5	Very dangerous	Failure could cause a major or permanent injury and/or serious system disruption with the interruption in service, with prior warning
4	Dangerous	Failure could cause a minor to moderate injury with a high degree of customer dissatisfaction and/or major system problems requiring major repairs or significant re-work
3	Moderate danger	Failure could cause a minor injury with some customer dissatisfaction and/or major system problem
2	Low to moderate danger	Failure could cause a very minor problem with no injury but annoys customers and/or results in minor system problems that can be overcome with minor modifications to the system or process
1	No danger	Failure causes no injury and has no impact on the system

Table 3 Detection rating scale (Silva et al., 2014)

Rating	Description	Definition
5	No chance of detection	There is no known mechanism for detecting failure.
4	Very remote/unreliable chance of detection	The failure can be detected only with a thorough inspection and this is not feasible or cannot be readily performed
3	Moderate chance of detection	There is a process for double-checks or inspections but it is not automated and/or is applied only to a sample and/or relies on vigilance
2	High chance of detection	There is 100% inspection or review of the process but it is not automated
1	Almost certain chance of detection	There are automatic “shut-offs” or constraints that prevent failure

The result of this assessment for every risk, as a risk priority was quantified using the RPN and the critical value, as determined by Equations 1 and 2:

$$RPN = (S \times O \times D) \quad (1)$$

$$\textit{Critical value of RPN} = \frac{\textit{Total RPN}}{\textit{Number of causes of risk}} \quad (2)$$

The risk with the highest critical value of RPN indicates the highest priority and should be given the greatest attention.

Determining alternatives

The analytical hierarchy process (AHP) method was implemented to determine alternatives to support the required strategy to reduce post-harvest loss of edamame. Experts or key persons (manager and assistant managers) were also involved in determining alternatives for improving postharvest handling to reduce postharvest loss, as an improvement to risk management in the supply chain activities. A questionnaire of pair-wise comparison using the judgment matrix (Table 4) was completed by some experts to support the required method in this study. Median values (2, 4, 6 and 8) were used for preferences.

The AHP method is a multi-criteria decision-making approach introduced by Saaty (2013), which consist of three main operations: hierarchy construction, priority analysis and consistency verification. The pair-wise comparison is implemented using a nine-point scale with preferences between available alternatives, such as equally, moderately, strongly, very strongly, or extremely preferred (Haq and Boddu, 2015). The compatibility index (CI), a natural measurement of existing information from the judgment in a matrix, was calculated using the Equation 3:

$$CI = \frac{\lambda_{max} - m}{m-1} \quad (3)$$

where lambda max (λ) is the highest value of the special vector or eigen value of a reversible matrix, *m* is the number of aspects (compared aspect) in a reversible matrix. RI is the random index, which is the value used to estimate consistency ratio (CR). RI for different values of *m* is provided by the generation of random matrices and measurement of the CI average (Saaty, 1995). These values are given in Table 5.

Table 4 Judgment matrix

Level of significance	Numerical value
Equally important	1
Moderately more important	3
Strongly more important	5
Very Strongly more important	7
Extremely more important	9

Table 5 Index of accidental incompatibility

m	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Calculated using Equation 4:

$$CR = \frac{CI}{RI} \quad (4)$$

In this study, consistency in the results of the pair-wise comparison was required to ensure accurate data information. The consistency test of judgments was based on a CR value being less than 0.1 considered as judgments being consistent.

The structure of the hierarchy using the AHP method consists of focus or goal (level 1), factors or criteria (level 2), actors (level 3), objectives (level 4) and alternatives (level 5). In addition, in this study, the structure of hierarchy and the proposed alternative with the highest priority was developed as a proposed strategy to reduce post-harvest loss in edamame.

Results and Discussion

Identification of risk source in postharvest loss

The harvesting process consisted of several activities (picking, weighing and transport from farm to processing unit). Identification of the risks and causes at the farm level aimed to minimize quantity losses of edamame during post-harvest activities. Discussion with key persons was required to obtain accurate information on post-harvest activities. This study found that the priority of risk sources in postharvest activities were human resources (workers), technology, nature and environment, and plants (Fig. 1).

Regarding discussion with key persons, in terms of workers, the skill of workers in harvesting activities plays an important role in maintaining the quality of the edamame product. Fig. 1 shows that the low skill of workers, such as in the picking activity, would affect the quality of the product, the quantity and the length of work in the harvesting process. In terms of the technology used in harvesting activities, the use of different kinds of tools and equipment was a priority in the harvesting process. These tools included a harvesting knife, basket, balance in the weighing process and transport facilities. Improper tools and facilities would affect the quality of edamame and productivity in the harvesting process. Nature and environment were important factors having a direct effect on the quantity and quality of edamame. The initial conditions of the plant seeds, planting and the growing process could also affect the quantity and quality of the edamame harvested.

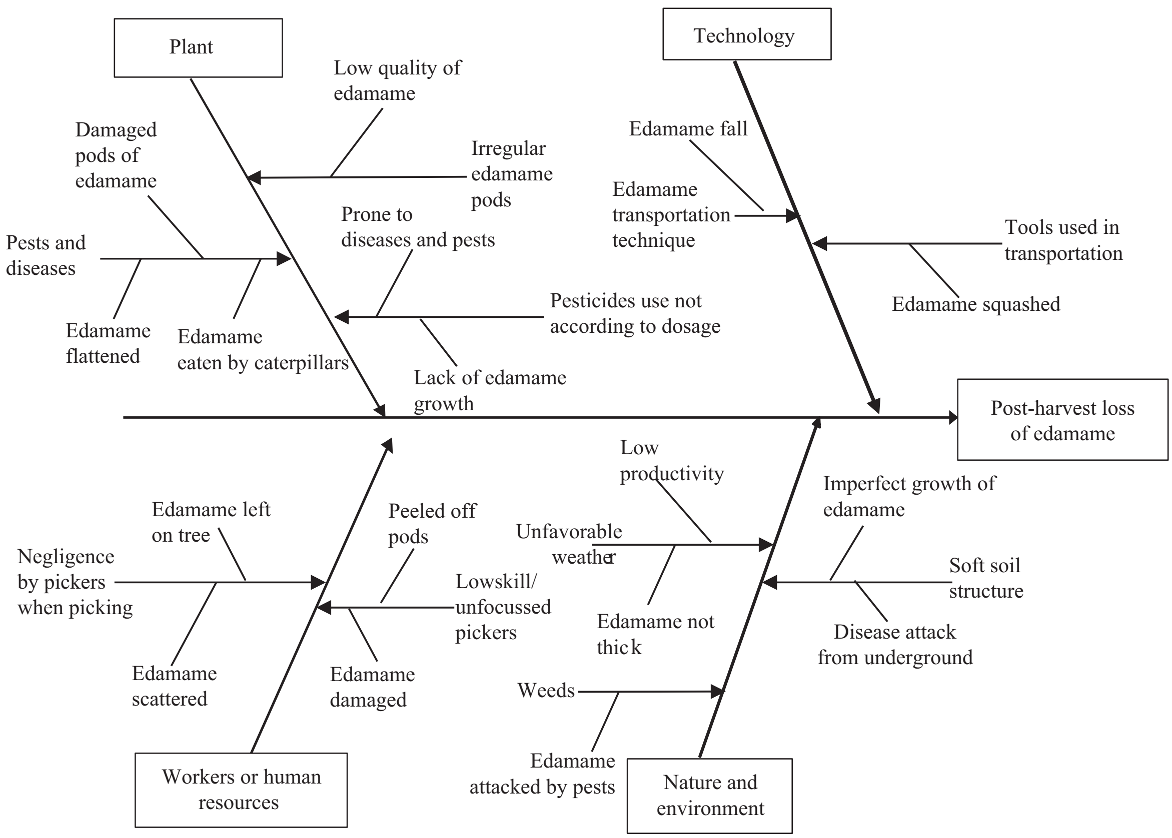

Fig. 1 Fishbone diagram of causes of post-harvest loss of edamame

Identification of causes of risk in postharvest loss of edamame

Causes of risks were determined from the sources of risks as human resources (workers), technology, nature and environment, and plants. The details of the causes of post-harvest loss risk are explained using the fishbone diagram in Fig. 1. In terms of human resources or workers, causes of post-harvest loss were the skill of workers (negligence by the workers) in the picking process, edamame left on the tree, peeled edamame and scattered edamame in the harvesting activity. Another study found that poor handling in post-harvest activities resulted in significant product losses (Kramchote, 2012). Tools and equipment used in the transport process, such as a harvesting knife, basket and weighing equipment, were causes of post-harvest loss, based on technological aspects. Transport and harvesting tools as factors influencing postharvest loss, were also reported by Mohammed et al. (2018). Improper tools and equipment produced defect edamame in the harvesting process. In the natural and environmental sources of risks, the important causes were climate, pests and diseases, and the structure of the soil and shrubs (wild plants). In terms of plant conditions, causes of post-harvest loss were pests and diseases, sprawled edamame (prone to diseases and pests, lack of edamame growth) and hollow edamame (low quality of edamame, irregular edamame pods). Underhill et al. (2017) explained that poor agronomic and post-harvest handling practices influenced the level of post-harvest horticultural loss. All these causes would directly affect the quantity of the post-harvest loss of edamame.

Analysis of causes of risks using failure mode and effect analysis

The FMEA method aims to identify and evaluate risks that have strong failure potential on the post-harvest loss of edamame. In-depth discussion with key persons (assistant manager, workers, group of picking workers) was used to identify the severity, occurrence and detection values required in this analysis. The RPN equation was used to determine the priority value of risk in post-harvest loss. Critical risks in the post-harvest loss were also shown using the RPN method. The RPN results are shown in Table 6.

Analysis of the RPN (with a total RPN of 246.62 from 10 causes of risks) resulted in a critical value of risks of 24.66. Thus, for this study, causes of risk with a value higher than 24.66 were considered as critical causes of risk in post-harvest loss of edamame. These critical causes were pests and diseases, low skill in picking process, shrubs (weeds) and usage of pesticides. All these critical causes of risk require more attention to reduce post-harvest loss in edamame. Similar factors in the study by Kassoa and Bekele (2018) identified climate and weather conditions, harvesting and handling techniques, transportation facility, disease and pest animals were major causes of post-harvest loss. Abass et al. (2014) reported that most farmers considered changes in weather (40%), pest damage in the field (33%) and storage pests (16%) as the three major factors that exacerbated post-harvest losses.

As a critical cause in post-harvest loss of edamame, improvement in handling was required to address these critical risks. In this study, pests and disease was the first rank of critical causes in post-harvest loss of edamame. Soybean pod borer (*Etiella zinckenella*) is an important pest in edamame plantation, which has been reported to occur in all soybean planting centers in Indonesia, with *E. zinckenella* as the widespread, dominant species causing yield losses of harvested soybean up to 80% (Soewanto et al., 2013). More alternative strategies to prevent post-harvest loss need to be implemented in postharvest activities.

Developing strategy on risk management using analytical hierarchy process

The AHP approach was used to develop the strategy of risk management to reduce post-harvest loss. The weighting process in AHP aimed to determine the priority level of factors/criteria, actors, purposes and alternatives in developing the strategic process. Table 7 shows the details of the pair-wise comparisons from key persons, weighting and priority ranking of factors in post-harvest loss of edamame.

Table 7 Pair-wise comparison result at factor level

Factor/criterion	Weight	Priority ranking
Pests and diseases	0.482	1
Skill of workers (negligence or workers)	0.249	2
Shrubs (disrupting plants, weeds)	0.168	3
Usage of pesticide	0.100	4

Table 6 Priority of risks in post-harvest loss of edamame

No	Cause of Risk	Score			RPN
		S	O	D	
1	Climate (weather)	2.86	3.04	2.79	24.26
2	Soil structure	2.84	2.84	2.65	21.37
3	Shrubs (disrupting plants, weeds)	3.22	3.06	3.00	29.56
4	Usage of pesticide	3.00	3.04	3.04	27.72
5	Pests and disease	4.04	3.43	3.47	48.08
6	Skill of workers (negligence of workers)	3.40	3.31	3.43	38.60
7	Low skill in picking process	2.65	2.59	2.88	19.77
8	Transport method on farm	2.70	2.38	2.54	16.32
9	Tools and equipment usage	2.45	2.25	2.29	12.62
10	Irregular pod shape of edamame	2.90	1.56	1.84	8.32
Total RPN					246.62

In term of factors, Table 7 shows that pests and diseases had the top priority ranking with the highest weight (0.482) compared to the other factors, indicating that it was the first priority for developing a strategy for post-harvest loss of edamame. Compared to other factors, pests and diseases need much more attention along with the handling process by the workers as a part of the harvesting activities in the field. This was consistent with the results of the study by Gonzales and Acedo (2015), who reported that in traditional and modern supply chains of vegetable products, the highest loss incurred at the farm level was caused by pre-harvest (pest problems). Riwthong et al. (2017) also found that, especially in commercial farms, pests and diseases were important sources of risk in commercial agricultural products (vegetables, fruit and flowers).

Based on Table 8, field workers were the primary priority for developing a strategy related to the actors having a strong involvement in post-harvest loss of edamame. In daily activities, field workers are responsible for different kinds of field jobs, such as spraying, irrigation and fertilization. As an actor in developing the strategy of post-harvest loss, field workers play a strong role due to their ongoing direct involvement from planting through to harvesting activities. A high skill level of field workers with better handling in fieldwork would reduce post-harvest loss of edamame. Goldsmith et al. (2015) stated that farm or field manager played a strong role in reducing loss.

Table 9 shows that the highest priority in developing a strategy on post-harvest loss at the purpose level was minimizing post-harvest loss. However, this main purpose should also be supported by the other purposes that maximize the profit and maintain the quality of edamame. In the whole process, planting and harvesting are at the beginning of the chain of edamame production. Therefore, post-harvest loss as a field problem should be prevented from the beginning of the process of edamame production. Better harvesting process management would reduce post-harvest loss of edamame.

In terms of alternatives as a part of the strategy of post-harvest loss of edamame (Table 10), controlling pests and diseases had the highest weight and thus the highest priority as the primary alternative in the strategy for controlling risks in post-harvest loss of edamame. This alternative would be followed by the other alternatives, such as periodically scheduled inspection of the harvesting process, controlling pesticide usage, field sterilization and skill improvement training of workers. The study by Acedo et al. (2015) reported that losses of vegetables were primarily due to pre-harvest activities, including insect damage, rotting or decay due to rain. This is relevant to the current study, as the company should also pay more attention to farm level activities (pre-harvest activities), such as controlling pests and diseases as a priority alternative.

The second priority ranking of alternatives was periodical inspection of the harvesting process of edamame. Through periodic and scheduled inspection of the harvesting process, work capacity, productivity of harvesting activity and worker skill, the error level of workers in the harvesting process could be directly monitored and quantity of spilled and defective edamame during the harvesting and transporting process could be minimized. Alternatives for controlling pesticide usage and field sterilization had similar weights. Pesticide usage and field sterilization would generally affect the growth and productivity of edamame. All these activities would be supported by the alternative of a training program for field workers. A training program would also improve field worker's skills regarding field handling, knowledge and management of pests and diseases, the picking process, handling in the transport process and handling at the processing unit. Hidayati et al. (2018) reported that other elements supporting increased productivity included working methods, application of technology, skill labor and supervision and these are relevant to the current study as the skill of workers and supervision (periodical inspection) are required to support the alternatives in this study.

Fig. 2 shows the hierarchy of strategies to reduce the risk of post-harvest loss of edamame at every level. This figure also indicates that the most important priorities at each level were pests and diseases (0.483) at the criterion level, field workers (0.408) at the actor level, minimizing post-harvest loss (0.346) at the purpose level and pest and disease control (0.242) at the alternative level. The alternative level in particular, has pests and diseases as the highest priority to prevent post-harvest loss of edamame. Weinberger et al. (2008) reported that developing disease management strategies was required, including understanding the etiology of post-harvest diseases in a specific commodity, such as edamame. This could be among the product handling methods that could be implemented from the field aspect in the edamame production process. This alternative should also be supported by field workers as the highest priority actors. A high skill level of field workers is required, such as knowledge of pests and diseases, appropriate dosages of pesticide and scheduling of pests and disease control. In terms of agri-food system, Nazir (2017) explained that any strategy for sustainable agri-production must pay particular attention to farming production input, such as pesticides, herbicides and chemical usage. All these are programs are related to the reduction of post-harvest loss of edamame in this study.

Table 8 Pair-wise comparison result of actor level

Actor	Weight	Priority
Field workers	0.408	1
Picking workers	0.232	2
Assistant manager (*Mandor*)	0.212	3
Field manager of edamame	0.148	4

Table 9 Pair-wise comparison result of purpose level

Purpose	Weight	Priority
Minimizing post-harvest loss	0.346	1
Maximizing profit	0.231	2
Maintaining quality	0.218	3
Maximizing production	0.206	4

Table 10 Pair-wise comparison result of alternative level

Alternative	Weight	Priority
Controlling pests and diseases	0.242	1
Periodical inspection of harvesting process	0.220	2
Controlling pesticide usage	0.186	3
Field sterilization	0.185	4
Skill improvement training of workers	0.167	5

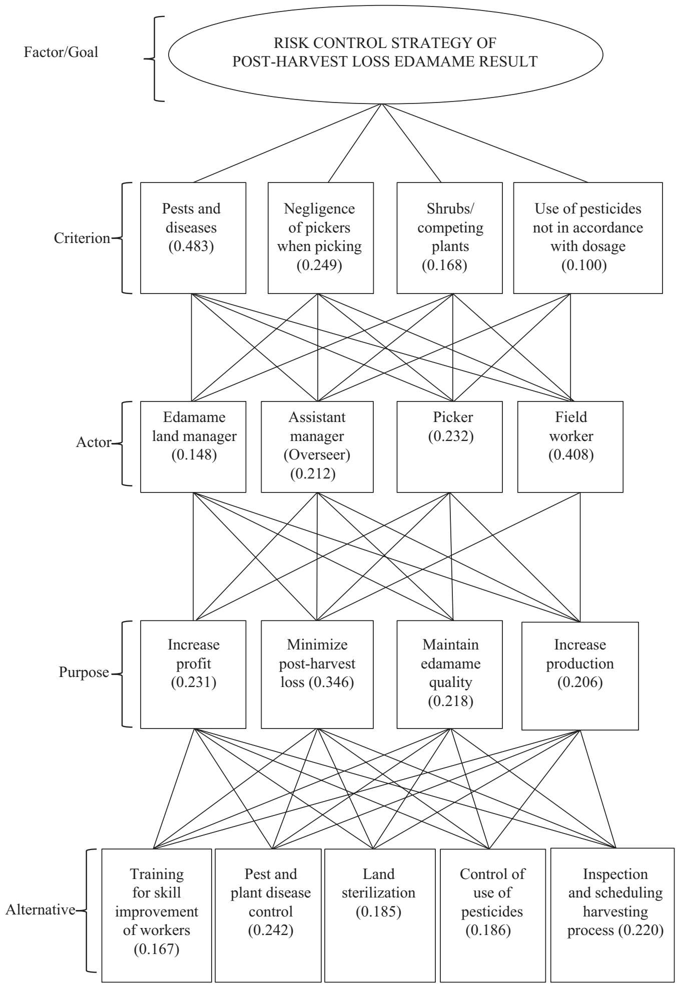

Fig. 2 Hierarchy of strategies for reducing post-harvest loss of edamame

Proposed recommendations

Activities that are required in pest and disease control in post-harvest loss of edamame include a scheduling and monitoring system. A scheduling system is implemented for prevention of pests or diseases that are difficult to detect using direct observation, such as *Agromyza* and *Etiella*. Control could involve direct eradication through spraying activity using pesticides at a certain phase or period of plant development when the pest or disease starts attacking edamame. Table 11 shows the schedule for a pest and disease control system for edamame with the recommended pesticides and their concentrations that could be applied for edamame.

This schedule (Table 11) could help field workers to control pests and diseases, thus preventing post-harvest loss of edamame. Spraying activity should also be conducted punctually by field workers according to the days after planting in the schedule.

Table 12 shows the pesticide spraying guidelines for edamame, which should be followed by field workers. Spraying activity uses a tank with 14 L volume capacity, which is common over a wide area of edamame plantations. The number of beds sprayed varies, depending on the day after planting. This pesticide spraying activity could be conducted in the morning from 05.00 hours to 09.00 hours and in the afternoon at 15.00 hours. Scheduling spraying activity is required throughout the field work group to ensure conformation to the time schedule and bed location for spraying activities.

In the monitoring system, the field manager or supervisor plays a lead role in controlling plant condition in terms of pest and disease attack. Monitoring activity could be conducted by observing the symptoms of pest and disease attacks on plants. Daily reports from field workers are necessary to support this monitoring system. Implementation of the schedule and dosage for spraying activity should be monitored by the field manager or supervisor. Brief daily discussions and periodical meetings with field workers could provide support for this monitoring system.

A training program is required for field workers related to improvement of their knowledge and skill in controlling pests and diseases, to prevent errors in spraying activities. This also ensures that the appropriate dosages of pesticides and the schedule of spraying activity are properly implemented by the field workers.

Table 12 Pesticide spraying guidelines

Days after planting	Number of seedbeds to spray (using 14 L sprayer tank)
5	28
10	26
15	24
20	22
25	19
30	16
35	14
40	12
45	10

Table 11 Scheduling of pest and disease control

Pest	Days after planting	Recommended pesticides (concentration)
Agromyza sp.	14	Deltamethrin/Fiphronil (2mL/L)
Agromyza sp.	21	Deltamethrin/Fiphronil
Etiella sp.	28	Methomyl/Thiodicarb (2mL/L)
Etiella sp.	38	Methomyl/Thiodicarb
Disease		
Rust (*Phakopsora pachyrhizi*)	11	Kaptan/Dithane (3g/L)
Cercospora	31	Mankozeb (1.5g/L)
Anthracnose (*Colletotrichum dematium*)	51	Propineb (2.5g/L)
Fusarium	1–10	Metiltiofanat (1.5mL/L)
Phytium	11	Metiltiofanat (1mL/L)

There were 10 causes of risk for post-harvest loss of edamame. Of these, four critical risks with high priority levels were pests and diseases, skill of workers (negligence of workers), shrubs (control of wild plants) and usage of pesticides. In the risk control of post-harvest loss, field workers were the top priority actor playing a major role in reducing post-harvest loss. In the alternative level of strategy, pest and plant disease control was the most important alternative required to prevent post-harvest loss of edamame. The proposed recommendations to support the strategy were scheduling of pest and disease control or monitoring activities, appropriate dosage of pesticides and a training program related to improvement of field workers knowledge in controlling pests and diseases.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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