JPPIPA 8(Special Issue) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Risk Control of Moon Orchid Production Using FMEA Method and Fishbone Diagram

Zumi Saidah[1]*, Nur Syamsiyah[1], Abhyasa Luthfi Hardhiawan[1]

[1] Department of Socio-Economic Agriculture, Faculty of Agriculture Unpad, West Java, Indonesia.

Received: October 28, 2022
Revised: November 25, 2022
Accepted: December 5, 2022
Published: December 10, 2022

Corresponding Author:
Zumi Saidah
zumi.saidah@unpad.ac.id

DOI:
10.29303/jppipa.v8iSpecialIssue.2506

Abstract: One type of orchid that is known to the public is the type of Phalaenopsis amabilis or the moon orchid. Orchid cultivation is inseparable from production risks that are influenced by internal and external factors. This risk allows the occurrence of an event that may cause losses. This study aims to identify sources of risk, analyze sources of risk priority management, and propose actions to control the production of Orchid Bulan. This research was conducted by Salsa Orchid, located in Cihideung Village, Parongpong District, West Bandung Regency, West Java Province. Identification and analysis of the impact of the risks posed are analyzed using the Failure Mode and Effect Analysis (FMEA) method, while to analyze the source of risk that is a priority for treatment is analyzed using a Fishbone Diagram. The study results show that critical values that must be addressed immediately are insufficient sunlight, too close spacing, low level of labor discipline, and less strategic production locations. The proposed handling of the risk of lack of sunlight is carried out by adjusting the intensity of light from the existing shade according to the needs of the moon orchids. Spacing that is too close is overcome by rearranging the position of the spacing so that the orchid leaves do not cover one another. The low level of labor discipline is overcome by intensive supervision of the work and employee work results. Production locations that are not strategic are overcome by using air conditioners and blowers to regulate air circulation, temperature, and humidity in the greenhouse.

Keywords: Moon orchid; Incidence; Severity; Production

Introduction

Ornamental plants (floriculture) are one group of plants in horticulture besides fruits and vegetables. The Ministry of Agriculture has determined as many as 323 types of horticultural commodities consisting of 60 types of fruits, 80 types of vegetables, 66 types of biopharma (medicinal plants) and 117 types of ornamental plants (floriculture) (Wahyudie, 2020) Floricultural production in Indonesia tends to increase due to the by the large demand for these commodities. Therefore, efforts to increase floriculture production continue to be carried out by expanding the harvest area and increasing productivity.

Floricultural plants are primarily an asset that still has a great opportunity to be further developed both in terms of quantity and quality. Floriculture itself can basically be grouped into two commodities, namely cut flowers (stalks) and ornamental plants (trees). Table 1 shows the prospects for ornamental plant agribusiness, in West Java, which have the potential to grow and develop. It is clear that orchids as a floriculture agribusiness sector offer very attractive prospects. Referring to the 2017 Directorate General of Horticulture Performance Report, over the past six years the trend of the floriculture sector, especially cut flowers, has placed orchids in the fourth position. The first sequence is occupied by chrysanthemums, followed by roses and tuberose.

Razaq et al., (2015) stated that orchids are ornamental plants that are in great demand because the shapes and colors of the flowers vary and can be used as cut flowers, potted plants, or plant elements. Meanwhile, the province with the largest orchid production in East Java with a production of 4.25 million stalks, 36.38% of the national orchid production in 2020.

How to Cite:
Saidah, Z., Syamsiah, N., & Hardhiawan, A. (2022). Risk Control of Moon Orchid Production Using FMEA Method and Fishbone Diagram. *Jurnal Penelitian Pendidikan IPA*, *8*(SpecialIssue), 87–95. https://doi.org/10.29303/jppipa.v8iSpecialIssue.2506

The second position is occupied by West Java with production reaching 4.08 million stalks or 34.91%. After that, there is Banten with orchid production reaching 1.36 million stalks or 11.62% (Badan Pusat Statistik RI, 2020). Orchid production in West Java is concentrated in two regions, namely Bandung Regency and West Bandung Regency (Figure 1).

Table 1. Data on the Production of Ornamental Plants (Floriculture) in West Java

Commodity	2019	2020	2021
Cut Orchid (Stalk)	5 697 821	4 078 121	4 836 753
Anthurium Flower (Stalk)	2 942 626	687 387	1 321 682
Carnation (Stalk)	1 237 376	784 300	-
Gerbera/Herbras (Stalk)	30 182 938	10 116 543	8 046 065
Gladiolus (Stalk)	1 278 595	1 940 785	-
Heliconia/Banana (Stalk)	221 310	165 364	240 614
Chrysanthemum (Stalk)	179 629 271	140 056 393	100 221 422
Roses (Stalk)	25 658 550	18 711 871	11 588 150
Tuberose (Stalk)	6 443 065	6 958 623	3 964 822
Dracaena (Tree)	7 831 380	7 999 771	12 276 094
Jasmine (Tree)	38 680	10 856	-
Palms (Tree)	54 579	65 788	18 213

Source:(Badan Pusat Statistik (BPS), 2021)

Figure 1. Orchid Production by Regency/City in West Java

The existence of orchids is currently not only used as home decoration or plants that can provide satisfaction in the form of beauty but also as a hobby, even being one of a business opportunity that has been proven to last until now. An orchid is a work of art that has high economic value because it contains many meanings and is the art of life.

There are several types of orchid plants that are relatively dominant and developed for both domestic and export markets, including Cattleya Lisa annex Lucky Strike and Temanggung Beauty Brasco Pacto Cattleya; Phalaenopsis, a cruciferous variety with blackish purple and stripe; Doritaenopsis; Meltonia sp and Odontoglatum; and Dendrobium (Putra DAO, 2018). Orchid cultivation, especially the moon orchid (Phalaenopsis amabilis) is a popular genus among orchid lovers (Handini et al., 2012; Razaq et al., 2015). However, such a prospective orchid production and distribution business is also faced with various types of risks as indicated by fluctuations in production. Orchid production reached 11.68 million stalks in 2020, but this number decreased by 37.22% compared to 2019 which reached 18.61 million stalks (Badan Pusat Statistik RI, 2020). The high interest of consumers in the moon orchids causes high aspects of production to meet market demand, but the high interest in the moon orchids does not seem to be matched by productivity (Cahyaningsih et.al, 2019). This is caused by the inhibition of orchid propagation. The unique structure of orchid flowers makes it difficult to pollinate naturally, the seeds produced from pollination are seeds that do not have endosperm so germination must be assisted by mycorrhiza (Bazand et al, 2014).

Various problems in producing high-quality orchids arise starting from flower resistance of ± 2 weeks, requiring serious post-harvest handling, especially packaging, transportation, and marketing (Widyastuti, 2018). Balilashaki et. al (2014) said that the production of plantlets by micro-propagation is one of the main problems in the cultivation and breeding of phalaenopsis and other orchids. In addition, in managing their business, orchid farmers are also faced with production risks caused by weather conditions, pest and disease attacks, gene mutations, plants that grow non-uniformly (stagnant), and mechanical damage (handling). The existence of this production risk certainly creates uncertainty about the benefits that will be obtained by farmers.

In general, previous research on moon orchids has mostly examined the production of moon orchids. A study conducted by (Razaq et al., 2015) examined increasing the size and quality of moon orchid flowers. Another study was conducted by (Utami et al., 2007) on the structure and pattern of somatic embryo development (embryogenesis) of the lunar orchid species Ph amabilis (L) Bl. in vitro. In addition, (Aditya et al., 2010) also conducted research on orchid cultivation, especially in the management of Phalaenopsis orchid nurseries. Risk research on other types of orchids was found in a study (Wisdya, 2009) that analyzed the production risk of Phalaenopsis orchids in specialization and diversification activities using mericlone and seedling seeds. Until now research on production risks in the moon orchid has been found so the authors are interested in conducting this research.

The novelty of the research in this paper is that it combines the FMEA method and the Fishbone diagram to describe the complete risk of lunar orchid production. The combination of these two methods is expected to increase orchid production through risk identification and production failure control so that it can help farmers analyze the cause and effect of a problem and find the right solution. Risk management is important to do in order to reduce the impact of risk on moon orchid farming. Therefore this study aims to: (1) identify sources of risk in the production of lunar orchids; (2) Analyze the source of risk which is a priority for treatment; (3) Proposed actions that can be implemented to control risks.

Method

This research was conducted at Salsa Anggrek which is located in Cihideung Village, Parongpong District, West Bandung Regency, West Java Province. The location selection was done deliberately with the consideration that Salsa Orchid is one of the largest orchid producers in the Bandung area. Respondents in this study were farmers and several parties who mastered (experts) in the cultivation of moon orchids with the selection of respondents using a purposive sampling method. The considerations used to determine experts are the appropriateness of education, experience, and track record expertise. Data collection was carried out using an interview guide to find out the sources of risks that occur, how often risks occur, the impacts they cause, and the efforts made to control losses due to production risks.

The first step in this research was carried out by identifying risk sources for the production of moon orchids. Identification of these risk sources is done by collecting data using an interview guide. The next step is to calculate the impact arising from production risk sources. This impact calculation is carried out using the Failure Mode and Effect Analysis (FMEA) method by calculating the likelihood, impact, detection, risk score, and risk priority number (RPN) values. The last step is done by determining the priority of the main risks that must be addressed first, using the Pareto diagram. After knowing the risk priorities, a descriptive analysis was carried out using a fishbone diagram to determine the right strategy to manage the risks that occur during the production process of the moon orchids.

The first objective in this study was carried out using data tabulation and descriptive presentation taken from the results of interviews with the respondents. The second objective in this study was analyzed using Failure Mode and Effect Analysis (FMEA). Risk analysis can also be carried out by mapping the risk level using a risk level map as was done by (Lestari et al., 2018). In this study, the FMEA method is a risk analysis technique used to evaluate the consequences of failures and prioritize failures in relation to the effects that occur (Badariah et al., 2011). Following are some of the steps that must be taken in analyzing risk using FMEA:

1. Identify the causes of risk by classifying risk sources. The identification process is carried out by dividing several events and determining the failure mode of each component and its impact.
2. Provide an assessment (rating) of the seriousness of the effects (critical effects) based on the severity (severity). Every failure that arises will be assessed for how big the level of seriousness is.
3. Determine the causes of failure and estimate the probability of each failure occurring. Occurrence rate.is a failure mode according to the probability of occurrence where the rating value is adjusted to the estimated frequency or a cumulative number of failures that can occur?
4. Identify approaches to failure detection and evaluate the system's ability to detect failures before they occur. Determine the level of detection (detection) of each failure mode.
5. Chen, (2007), said that the FMEA assessment was carried out using the Risk Priority Number (RPN) which was obtained through equation (1).

$$RPN = Severity\ (S) \times Occurrence\ (O) \quad (1)$$

6. In addition to calculating RPN to find out the priority value of risks that must be handled immediately, also calculating the Risk Score Value (RSV) to find out the value of the highest cause of a failure which is obtained through equation (2)

$$RSV = Severity\ Score \times Occurrence\ score \quad (2)$$

7. Based on the results of these calculations, then analyzed using diagrams.
8. Pareto to find problems or causes that are the key to solving problems. In order to obtain the risks that must be prioritized to be addressed, a scatter plot is to determine the dominant causes of each RPN and RSV which are then validated and grouped.
9. Then from the risk assessment process, namely knowing the priority of risks that occur in farming based on the RPN and RSV values in order to determine which risk causes must be addressed first. These risk priorities are used to determine risk control measures for each event that is plotted on the scatter plot.

The third objective analysis fishbone diagram. Fishbone diagrams/Ishikawa diagrams or often also referred to as cause-and-effect diagrams are used to formulate causes and effects of production failures in lunar orchids. Asmoko, (2013) Says that a fishbone diagram is a tool used to identify, explore, and graphically describe in detail all the causes associated with a problem. The Fishbone diagram is an analysis tool that provides a systematic way of looking at effects and the causes that create or contribute to those effects (Ilie & Ciocoiu 2010). Because of the function of the Fishbone diagram, it may be referred to as a cause-and-effect diagram (Watson, 2004).

Making a fishbone diagram can be done with the following steps:
1. Draw a diagram with problem questions placed on the right side (forming a fish head), and the main category as large bones, in this study, namely the group of problems that occur in the production of moon orchids.
2. Assign each cause to the appropriate main category, placing it in the appropriate problem branch.
3. Determine the causes that might occur, to find the root causes, then list the root causes in the branches according to the main category (forming the small bones of the fish).

Result and Discussion

Identification of Risk Sources in Moon Orchid Production

Farming risk is something that cannot be avoided in a production process, especially farming that involves nature and other things that cannot be predicted in the implementation process. The source of risk is the main source of the cause of a failure. Every risk that arises, whether it has a small or big impact, will affect orchid farming in Salsa Anggrek. Identification of production risk sources can be done by brainstorming from literature such as books and guides on orchid cultivation, orchid pests and diseases and their handling, scientific journals on the risks of orchid flower production, as well as direct interviews with farmers and experts.

Based on the results of the brainstorming and interviews conducted with the respondents, 29 sources of risk for the production of moon orchids were found in Salsa orchids. These risk sources are divided into five categories, namely: (1) risk sources from production inputs; (2) sources of risk from production (cultivation); (3) sources of risk from plant pests & diseases; (4) sources of risk from harvest & post-harvest; and (5) sources of risk from human resources and (6) sources of risk from the environment. The classification of the production risks of the lunar orchids can be seen in Table 2.

Table 2. Identification of Moon Orchid Production Risk

Production Risk Category Production	Risk Source
Production inputs.	Unstable seed quality
	Limited fertilizer
	Less land area
	Limited seed additions
Source of risk from production (cultivation)	Spacing too close
	Poor watering
	The technology used is not optimal
	Garden cleanliness not optimal
	There is no measurement of substances in the planting medium
Source of risk from pests & plant diseases	Irregular pesticide application schedule
	Bacteria in orchid seeds
	Pests on orchids
	Diseases on orchids
Sources of risk from harvest and postharvest	Delay in payment from consumers
	Products damaged due to packing
	Wire provision when forming flowers
Source of risk from human resources	Low level of labor discipline Low
	No SOP with the employees
	Labor does not focus on one area
	Mistakes made by employees are often repeated
	No skilled workforce
Sum risk from the environment	Less strategic production location
	Greenhouse construction is not optimal
	Unstable temperature
	Less sunlight
	No cooling
	No humidity control machine
	Unstable weather and climate
	Occurrence of a major wind disaster

Risk Management Strategy for Moon Orchid Production

After all sources of risk are identified, steps are taken The next step is to assess all risks. The assessment method uses Failure Mode and Effect Analysis (FMEA) by calculating the risk value of each source of production risk. The assessment is carried out by giving a rating or score for the severity of the failure effect (severity), the frequency of occurrence of the cause of failure (occurrence), and the ability to detect causes (detection).

After detailing the production risks of the moon orchids at Salsa Anggrek, then detailing some of the risks that have the highest RPN and RSV is done. Table 3 shows that of the 29 risk causes for the production of lunar orchids, the 9 highest values are obtained for the priority values of risks that must be addressed immediately.

Table 3. Production Risk of Moon Orchid with the Highest RPN Value

Cause of Farming Risk	*Sev.*	*Occ.*	*Det.*	RPN
Lack of sunlight	8	10	9	720
Planting distance too close	8	9	9	648
Low level of labor discipline	8	9	8	576
Less strategic production location	8	9	8	576
Addition of limited seeds	8	8	8	512
Provision of the wire during the formation of flowers	7	10	7	490
Pests on orchids	8	5	9	360
Watering is not good	9	8	5	360
Building construction is not optimal	7	6	8	336

Notes:
Sev. : Severity (severity of failure effect)
Occ. : Occurance (frequency of events causing failure)
Det. : Detection (ability to detect the cause of failure)
RPN: Risk Priority Number Table

Table 4 shows the calculation of the highest RSV value of the 29 monthly orchid production risks to determine the value of the highest risk cause. Table 3 and Table 4, it can be explained several factors that cause production risk in the lunar orchid.

Table 4. Production Risk of Moon Orchids with the Risk Score Value (RSV)

Causes of	*Sev.*	*Occ.*	*Det.*	RPN
Not enough sunlight	8	10	9	80
Labor discipline is not good	8	9	8	72
Production location is not strategic	8	9	8	72
Planting spacing is too close	8	9	9	72
Watering is not good	9	8	5	72
Giving wire when forming flowers	7	10	7	70
Addition limited seedlings	8	8	8	64
There is no measurement of substance in the planting medium	7	9	3	63
Building construction is not optimal	7	6	8	42

Description:
Sev. : Severity (severity of failure effect)
Occ. : Occurance (frequency of events causing failure)
Det. : Detection (ability to detect causes of failure)
RSV: Risk Score Value Based

Less sunlight. Exposure or light intensity can affect the growth of the moon orchid. The lack of light intensity for the moon orchids in Salsa Anggrek is due to the obstruction of sunlight because the location of Salsa Anggrek is in a densely populated settlement so the entry of sunlight is blocked by residents' houses. Phalaenopsis is a type of epiphytic orchid that requires shade from direct sunlight and likes moist environmental conditions, therefore the moon orchid (phalaenopsis) requires 20%-50% sunlight intensity. This is in line with research (Sukma, 2009) said that Phalaenopsis requires low light around 1500-3000 FC (300-600 µmols-1m2). In addition, this orchid also requires about 40% shade and 12 hours of light.

Plant spacing. The planting of moon orchids needs to pay attention to the spacing. Adjusting the spacing means giving the same or even living space for each plant. In addition, by adjusting the spacing, regular rows of plants will be obtained so that it is easy to manage plants. (Widyastuti, 2018) said that spacing will affect plant density or the number of populations per unit area. The planting distance between orchids is preferably 10 cm (Dinas Pertanian Banten, 2022) depending on the type of orchid. Plant population affects relative growth and net photosynthetic yield. This is closely related to the capture of light energy, and the availability of nutrients and water in the soil. Thus plant density will determine crop production.

Labor discipline. Cultivated moon orchids require care and maintenance so that they can grow and develop as expected. Flower care can affect plant productivity and the quality and quantity of flower production produced (Widyastuti, 2018). Orchid plants require good care because to produce quality orchids, the humidity of the orchid planting medium needs to be maintained as well as the need for light intensity, fertilization, and orchid flower health. Labor indiscipline in caring for orchids can result in moon orchids not growing properly and the quality of the plants is not optimal.

The production location is less strategic, this is because the location of Salsa Orchid is in a densely populated area, thereby blocking air circulation and affecting humidity and temperature in the greenhouse. The choice of location for orchid cultivation should pay attention to several things so that it can guarantee optimal growth of orchids (Direktorat Buah dan Florikultura, 2020).

Limited seed additions. Limitations on the quality and quality of the moon orchids produced at Salsa Anggrek are still limited. The limited quality of moon orchid plant products comes from seeds produced in collaboration with other parties. The Phalaenopsis amabilis orchid can be propagated by vegetative (split and tissue culture) and generative (seed) methods. In general, vegetative propagation is highly preferred because the orchid will flower more quickly and the characteristics of the new orchid will be the same as the parent.

Another risk faced by Salsa orchids is the provision of wire when forming flowers. The provision of wire to the orchids of the moon is done when the length of the stem is 20-25 cm and when the condition of the stem is still elastic so that it can be arranged to grow following the direction of the wire. The purpose of giving the wire is so that the flower stalks of the moon orchid are not easily broken and beautify the appearance of the flowers. Proper provision of wire is very important for the quality of the orchid because it can affect the orchid flower. The wire used for the support is 0.5 cm in diameter and the length of the support is adjusted to the length of the orchid flower stalk (Rohman, 2019). The wire used is made of stainless steel which is not rusty.

Pests on orchid plants. Pest and disease control is an important aspect of orchid cultivation. Control of pests and diseases is carried out chemically using fungicides, bactericides, and insecticides, as well as carried out mechanically, namely by removing and destroying pests directly. Pest and disease control must pay attention to the pesticides used (Aditya et al., 2010) Spraying for orchids that are attacked by pests needs to be repeated 3 times with a certain period of time (for aphids) spraying once a week (Son, 2009). Pests on moon orchids have a significant impact because they can cause the orchids to die and reduce their quality of the orchids.

Poor watering. Each orchid has a different humidity level, so the watering needs to be done with great precision. Salsa Anggrek provides criteria for the humidity level of the plant media based on the color of the planting media and checking by touching/ inspecting the planting media. Watering the moon orchid plants needs to pay attention to weather conditions and the humidity level of each planting medium. According to (Putra, 2009) said that the watering of the moon orchid is done according to weather conditions, if the sun is very hot, then watering twice a day (morning and evening), but if it is the rainy season, the orchid does not need to be watered. The need for water depends on the type of plant, plant size, media type, pot type, air temperature, air humidity, and wind speed (Aditya et al., 2010)

Building construction is not optimal. building construction greenhouse used in Salsa Anggrek uses wood. Other Orchid companies use steel and concrete to construct greenhouse buildings. The choice of wood as the greenhouse was chosen because the initial costs incurred are lower than using iron and concrete. The use of wood resulted in less sturdy construction. The use of wood has an impact on the life of the greenhouse because the wood is easily weathered and the height of the greenhouse is limited. To strengthen the construction, additional supports in the form of wood are needed greenhouse which can interfere with the sunlight entering the greenhouse.

In addition to assessing the factors that cause product failure or risk in lunar orchids, Figure 2 shows there are four risks that have a value above the critical value. This critical value shows that the four risks are risks that must be handled first and have a high cause. The four risks are insufficient sunlight, too close spacing, low level of labor discipline, and less strategic production locations.

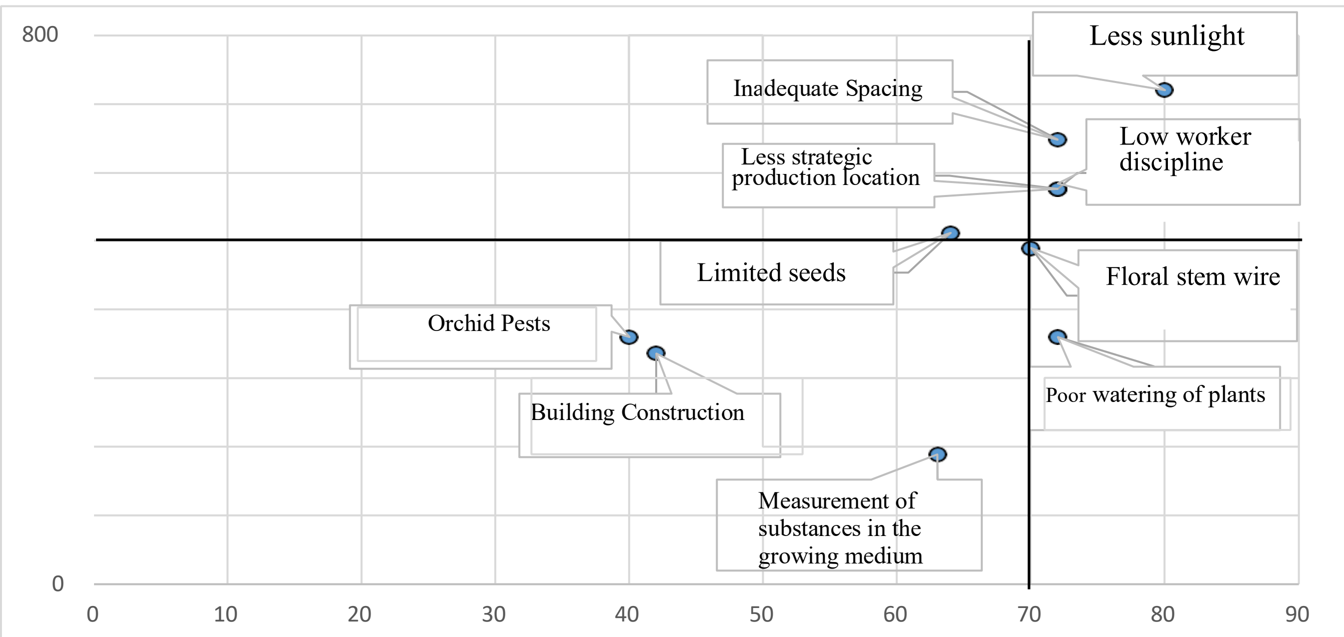

Figure 2. Scatter Plot Diagram Based on RPN and RSV

Developing a Risk Management Strategy for Moon Orchid Production

Identification of causes for the occurrence of sources of moon orchid risk is carried out by using a cause and effect diagram or fishbone diagram. Basically, cause and effect diagrams are used to identify the root causes that may arise from a problem. After the root of the problem has been identified, appropriate actions can be determined to address it. Based on the results of the identification of existing problems, it can be identified several factors causing the production risk of the lunar orchids. input risk, production risk, pest & disease risk, harvest, and post-harvest risk, environmental risk, and human resource risk.

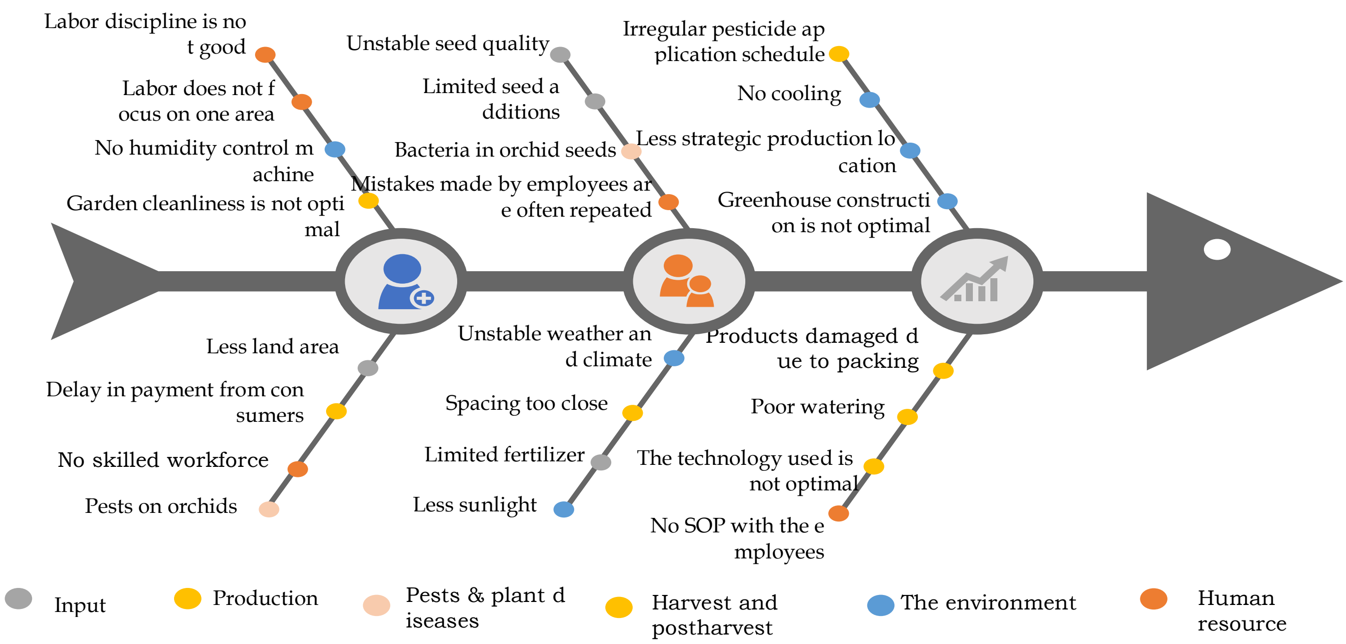

Figure 3. Sources of Risk in Moon Orchid Plants

Losses caused by input risk sources come from the insufficient land area, limited availability of fertilizers, limited addition of seeds, and unstable seed quality. The way to overcome the lack of land area can be done by renting new land. The addition of quality moon orchid seeds can be done by partnering with an orchid seed company. To get good quality orchid seeds, you must pay attention to humidity, have lots of roots and provide organic fertilizer.

Sources of risk originating from production activities (cultivation) identified in the planting of moon orchids will have a negative impact if they occur in the middle of production. Overcoming the problem of spacing that is too close can block sunlight for orchid growth as well as losses caused by sources of pest & disease risk from pests that attack moon orchids such as mites, slugs, grasshoppers, elephant beetles, red mites, ants, aphids, millipedes, and so on. The disease that often occurs in orchids is a fungus. The fungus often appears due to weather conditions that are too humid (Tamandala, 2014).

Losses caused by sources of risk of harvest & post-harvest come from damage during packing and when wires are attached to the orchid flowers. Age of flowering orchid plants, depending on each type. In general, adult orchid plants flower after 1-2 months of planting.

Losses caused by sources of environmental risk mainly come from the location of the moon orchid production which is located in a residential area and the greenhouse is directly next to the residents' houses. This of course will affect the growth of the moon orchid. The Phalaenopsis amabilis orchid has certain requirements in order to thrive and have beautiful flowers. Basically, there are several optimal environmental conditions that cause moon orchids to grow well. These conditions are related to the intensity of sunlight, temperature, wind, and water (Putra, 2009).

Tamandala, (2014) said that Human Resources (HR) is a production factor that is very supportive in the cultivation process because all activities are carried out with human assistance as HR. Sources of risk originating from human resources are caused by human errors and negligence of employees who do not follow the SOP. Several mistakes in handling by SDM led to the slow growth of orchids, damaged plants, and even caused the death of moon orchids. The loss of value from the negligence of human resources illustrates that the decrease in production due to negligence of human resources affects revenue (Evotianus, 2019).

Conclusion

Based on risk analysis using Failure Mode and Effect Analysis, there are 29 sources of risk in orchid flower production. These risk sources can be grouped into 6 categories. Priority risk sources or risk sources that must be addressed immediately are risk sources with a Risk Score value and Risk Priority Number above the critical value. The sources of these risks include insufficient sunlight, too close spacing, low level of labor discipline, and less strategic production locations. The proposed risk response action based on the fishbone diagram is to control the impact of the risk of insufficient sunlight being overcome by adjusting the intensity of the irradiation and also adjusting the shade so that the lunar orchids get the light according to their needs. Spacing that is too close is overcome by rearranging the position of the spacing so that the leaves of the orchid do not cover one another so that the phalaenopsis orchid can get optimal light. The low level of labor discipline is overcome by carrying out intensive supervision of the work and results of employee work. Production locations that are not strategic are overcome by using air conditioners and blowers to regulate air circulation, temperature, and humidity in the greenhouse.

Acknowledgment

This Research is part of the internship assistance activities carried out by students. Therefore we thank the partners of CV. Salsa Anggrek for his willingness to carry out internship and research activities.

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