

Production Risk and Management Strategies of Potato Farming in Nagari Alahan Panjang, Solok Regency, West Sumatera

Production Risk and Management Strategies

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ABSTRACT

Solok Regency is the largest potato-producing area in West Sumatra. However, from 2015 until 2020, potato production in Solok Regency has experienced a decline. The decline in potato production in Solok Regency indicates production risks in potato farming. The decrease in potato production could be caused by several factors related to potato farming, such as rainfall, pests, diseases, and others. This study aims to identify and assess the sources of production risks in potato farming and analyze risk management in managing production risks in potato farming in Nagari Alahan Panjang, Solok Regency. Data were collected from 31 potato farmers in Nagari Alahan Panjang, the village with the highest potato production in Solok Regency. This study used a risk mapping matrix to analyze the data. The results of the study found nine sources of production risk in potato farming, namely: poor seeds, high rainfall, expensive fertilizers, improperly weeding, caterpillar pests, thrips pests, pig pests, fusarium wilt disease, and phytophthora disease. This study formulates two types of risk management: preventive and mitigation strategies. A preventive approach is to prevent or reduce the frequency of risk by rotating crops properly and using organic fertilizers. A mitigation strategy is to minimize the impact of production risks by diversifying crops, utilizing biological agents of *Trichoderma* sp, applying proper Weeding, and partnering with certified potato seed breeders to get good quality seed.

Keywords: Horticulture, Mitigation Strategy, Preventive Strategy, Risk Map, Vegetable

ABSTRAK

*Kabupaten Solok, dikenal sebagai penghasil kentang terbesar di Sumatera Barat, akan tetapi terus mengalami penurunan produksi dari tahun 2015 dan terus berfluktuasi sampai sekarang. Hal ini menandakan adanya risiko dalam usahatani kentang. Penelitian di Nagari Alahan Panjang, wilayah dengan produksi kentang tertinggi di Solok, mengidentifikasi sembilan sumber risiko produksi dari 31 petani. Risiko tersebut meliputi benih jelek, curah hujan tinggi, mahalnya pupuk, penyiangan tidak tepat, serta serangan hama ulat, thrips, dan babi, juga penyakit layu fusarium dan phytophthora. Penelitian ini merumuskan dua strategi manajemen risiko. Strategi pencegahan berfokus pada pengurangan frekuensi risiko melalui rotasi tanaman yang tepat dan penggunaan pupuk organik. Sementara itu, strategi mitigasi bertujuan meminimalkan dampak risiko melalui diversifikasi tanaman, pemanfaatan agen hayati *Trichoderma* sp., penyiangan yang tepat, dan bermitra dengan pemulia benih bersertifikat untuk memperoleh benih berkualitas.*

Kata kunci: Horticulture, Mitigation Strategy, Preventive Strategy, Risk Map, Vegetable

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INTRODUCTION

Potatoes (*Solanum tuberosum* L.) are horticultural crops from the United States. This plant has high economic value and a stable market share. Potato plants are rich in protein and carbohydrates needed by the human body, so the demand for potatoes is very high. One of the areas in Indonesia with the highest potato production is Solok Regency in West Sumatra. In 2020, 62% of West Sumatra's total potato production was produced in Solok Regency (Yusmarni et al., 2023).

Solok Regency is located in the highlands of West Sumatra Province with an average altitude of 1,458 m above sea level. This area has climate and soil conditions that support the growth of horticultural crops, including potatoes. Solok Regency has made potatoes one of the region's leading commodities. Based on BPS data, Solok Regency is the largest potato-producing area in West Sumatra, producing 14,282.50 tons in 2020 (BPS, 2021). One of the central agricultural areas in Solok Regency for horticultural crops, including potatoes, is Alahan Panjang. This is based on the Decree of the Regent of Solok No. 520-232-2020 dated April 3, 2020, concerning the Determination of Agricultural Areas in Solok Regency.

Potato production in Solok Regency continues to fluctuate with a tendency to decrease yearly since 2015. In 2015, potato production reached 50,865.60 tons. In 2016, it decreased by 16 percent to 42,521.0 tons. The production experienced an increase in 2019 by 44 per cent from the previous year. However, in 2020, it experienced a considerable decline of 64 per cent (BPS, 2021).

Disruptions in potato production activities cause production fluctuations. These disruptions can be uncertain weather conditions and pest and disease disturbances that trigger crop failures, resulting in low yields. This fluctuating production indicates that potato farming is vulnerable to production risks. Production risk refers to the uncertainties and potential losses that arise during the production process of goods or services. Production risk relates to the uncertainties and potential losses associated with the agricultural production process. Agricultural production risk can impact yields, quality, and farm profitability (Boehlje and Gentry, 2012).

Things that often become production risks in potato farming are unpredictable weather changes, pest and disease attacks and difficulty in obtaining quality seeds. Weather changes that significantly affect potato production include excessive rainfall during the rainy season, which can cause land to be flooded, and high temperatures, which will also cause potato plants to experience drought during the dry season. Pest and disease disturbances can pose a risk of crop failure. If all sources of risk are not addressed as well as possible, it will result in crop failure or losses and can even result in the cessation of farming efforts being carried out by farmers. Therefore, risk management is needed so farmers can control risks well and prevent fatal losses.

Losses arising from production risks can be minimized by handling risks as well as possible. A profitable business is a business that has good risk management (Kountur, 2006:21). Managing production risk in agriculture involves employing strategies to mitigate uncertainties and minimize potential losses (Harwood, 1999)

LITERATURE REVIEW

The Production Risk in Agriculture

The agricultural sector has long been characterized by its inherent risks, primarily due to the nature of working with living organisms and their susceptibility to weather patterns and other natural occurrences such as pathogens and animal diseases. (Theuvsen, L. (2013). Agriculture, by its very nature, operates under a significant degree of uncertainty. The inherent biological processes involved in crop and livestock production are susceptible to many factors beyond human control, leading to what is broadly termed production risk. This review explores the existing literature on the sources, impacts, and management strategies associated with production risk in agriculture. It examines how researchers have conceptualized, analyzed, and proposed solutions to mitigate agricultural producers' vulnerabilities.

Production risk in agriculture stems from the variability in yields and output due to natural hazards and biological uncertainties. Weather variability, including droughts, floods, extreme temperatures, and storms, consistently emerges as a primary source of production risk across various agricultural systems. Studies have extensively documented the negative impacts of adverse weather events on crop yields, livestock productivity, and overall farm income (Hardaker et al., 2015).

The consequences of production risk extend beyond reduced yields and output. Financial instability is a significant concern for farmers facing production shocks, potentially leading to income volatility, difficulties meeting financial obligations, and increased vulnerability to poverty (Morduch, 1995). Production risk can also discourage investment in agriculture, hindering the adoption of new technologies and sustainable practices due to the fear of potential losses (Dercon, 2004).

At a broader level, aggregated production risks can significantly affect food security and market stability. Large-scale crop failures or livestock losses can lead to price spikes, supply shortages, and increased reliance on imports, impacting consumers and the overall economy (Schmidhuber & Tubiello, 2007).

Risk Management in Agriculture

Risk management in agriculture involves identifying potential problems and developing strategies to minimize their impact on farm businesses. Risk management in agriculture includes managing production risks like weather, pests, and diseases, as well as market risks like price fluctuations and financial risks like borrowing.

A substantial body of literature focuses on strategies to manage production risk in agriculture. These strategies can be broadly categorized into ex-ante (before the event) and ex-post (after the event) measures.

Ex-ante aims to reduce the likelihood or impact of production shocks. Diversification, both in terms of crops and livestock, is a widely discussed strategy to reduce the overall variability of farm income. By cultivating a variety of enterprises with different responses to environmental and biological stresses, farmers can buffer against localized losses.

Another preventive strategy is adopting improved farming practices, such as integrated pest management, conservation agriculture, and efficient water management techniques, which can reduce production risks by enhancing resilience to adverse conditions (Pretty, 2008). Furthermore, investments in infrastructure, such as irrigation systems and storage facilities, can help mitigate the impacts of weather variability and post-harvest losses (Lipton et al., 2003).

Crop and livestock insurance represents a key risk transfer mechanism, allowing farmers to pay a premium in exchange for financial compensation for production losses due to covered perils. The design and effectiveness of agricultural insurance schemes have been extensively studied, with debates surrounding issues such as moral hazard, adverse selection, and the role of government subsidies (Mahul & Stutley, 2010).

Ex-post strategies focus on coping with the consequences of production losses after they occur. These often involve informal community risk-sharing mechanisms, such as mutual support networks and credit arrangements. Government interventions, including disaster relief programs and social safety nets, also play a crucial role in assisting farmers affected by severe production shocks (Benson & Clay, 2004).

METHODS

The method used in this study is a survey method to obtain facts from existing symptoms and seek factual information. Data were collected from potato farmers in Nagari Alahan Panjang, a Solok Regency vegetable production center. Sampling was done using non-probability sampling with a purposive sampling technique, using the criteria of potato farmers who cultivated potatoes four times in the last three years. The number of samples used in this study was 31 potato farmers.

The types of data used in this study are primary and secondary. Primary data were obtained through interviews with sample farmers using questionnaires. Secondary data

are used to support the data. Secondary data are obtained from literature, previous research, books, and files from related institutions or agencies.

The analysis method used in this study is a risk map analysis. A risk map is a graph that describes the position of risk between two axes where the vertical axis represents the possibility, and the horizontal axis depicts the impact (Kountur, 2006). The graph of the risk map is divided into four quadrants. Quadrant one shows high frequency and effect, quadrant two shows high frequency and low impact, quadrant three shows low frequency and high impact, and quadrant four shows low frequency and impact.

Frequency refers to how often an event occurs that is a source of identified potato farming risk. The determination of the frequency value uses a scale of 1 to 3, as shown in Table 1 below.

Table1. Risk Frequency Category

Risk Frequency Category			
Scale	Probability	Risk probability indicators based on	
		Frequency of occurrence	Percentage
1	High	> 3 times	>80%
2	Medium	2-3 times	60% < p ≤ 80%
3	Low	< 2 times	40% < p ≤ 60%

Meanwhile, the risk impact refers to how much loss is caused by the risk source to potato production. The measurement of risk impact also uses a scale of 1 to 3, referring to Hery's research (2015:63) and Aisyah's research (2022:30). Potato plant production activities were observed four times during the planting season. The frequency of occurrence value is obtained by multiplying the percentage value by the total production activity. For example, the percentage is multiplied by the total production activity to get the occurrence frequency value on a scale 3. The rate of 80% is multiplied by the total production activity of 4 planting seasons so that the frequency result is three times, as well as for a scale of 2-1. The risk impact category is shown in table 2 below.

Table2. Risk Impact Category

Scale	Impact	Risk Impact Category
3	High	The loss was very high as 100% of the production was wasted
2	Medium	The loss is high, where 50% of potatoes are of poor quality
1	Low	Minor losses, where less than 50% of potatoes are wasted or of poor quality

Risk mapping refers to two dimensions: the frequency of risk and the impact of the risk. Risks are mapped based on the risk status. Risk status shows the sequence of risky events—the value of risk status results from multiplying frequency and impact (Kountur, 2006:102). A high status indicates a high risk, and a lower status indicates a lower risk. The position of the risk source can be seen in the risk map. The risk management strategy can be formulated after the risk mapping. There are two types of risk management strategies: preventive and mitigation strategies.

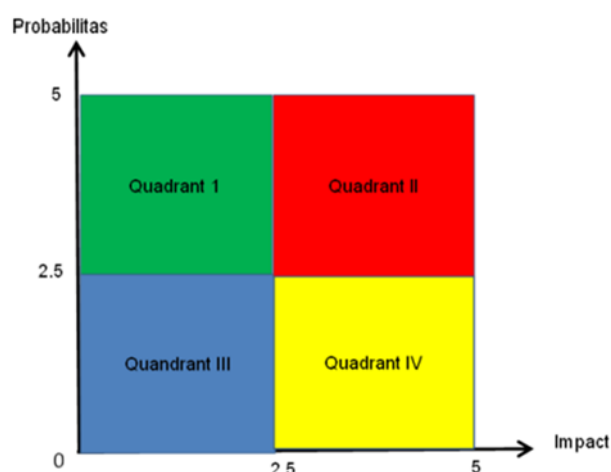


Figure 1. Risk Mapping by Kountur

RESULTS AND DISCUSSION

Production Risk of Potato Farming in Nagari Alahan Panjang, Solok Regency

The main potato-producing area in Solok Regency is Alahan Panjang, a sub-district with a cooler climate, making it suitable for cultivating potatoes and other highland crops. The fertile volcanic soil and the high-altitude conditions in Alahan Panjang contribute to the quality and quantity of potato production, making it a key supplier of potatoes for the region and various parts of Indonesia.

Potato farming in Solok is generally carried out on small to medium-sized family farms. Traditional farming methods are still widely used, though there has been a gradual shift toward more modern techniques to improve yields and efficiency in recent years. Farmers plant potatoes on terraced fields in highland areas, where the cooler temperatures and well-drained soil create optimal growing conditions. The use of organic fertilizers, combined with natural pest control methods, is every day, reflecting the sustainable agricultural practices that many farmers in the region adhere to.

Production risk analysis of potato farming in Nagari Alahan Panjang is carried out through 2 stages: identification and assessment of risk sources.

1. Identification of production risk

Risk sources are identified by grouping all possible risks in each potato cultivation process.

Table 3. Source of Production Risk in Potato Farming

Code	Source of Risk	Amount	%
A	Seed Preparation		
A1	Low seed quality	19	61.29
B	Planting and basic fertilizer application		
B1	High rainfall	31	100
C	Follow-up fertilization and hilling		
C1	Expensive fertilizer prices	22	70.97
D	Weeding		
D1	Improper Weeding	3	9.67
F	Pest and plant disease control		
F1	Caterpillar pest	30	96.77
F2	Thrips pest	17	54.84
F3	Pig pest	5	16.13
F4	Fusarium wilt disease	31	100
F5	Phytophthora disease	31	100

Based on Table 3, nine sources of production risk are found in potato farming in Nagari Alahan Panjang of Solok Regency. However, not all sources of risk are experienced by farmers, such as pig pests, which are only experienced by five farmers or 16.13% of the total sample farmers. Improper Weeding is only experienced by three farmers, or 9.67%

of farmers. The sources of risk experienced by all farmers are high rainfall, fusarium wilt disease, and phytophthora disease.

a. Seed Preparation

Farmers in Alahan Panjang have relatively difficulty obtaining potato seeds, especially good-quality ones. Farmers get good quality seeds from seed breeders, but the number of potato seed breeders in Nagari Alahan Panjang is minimal. Apart from breeders, farmers can also buy potato seeds from other regions, such as Sungai Penuh (Kerinci) and Pangalengan (Bandung). As a result, farmers will spend more money to obtain seeds because the shipping costs from outside the province are expensive. The lack of seed availability has made some farmers decide not to plant potatoes until they have potato seeds. Another option that farmers make is to buy local seeds that are unguaranteed and of poor quality. Based on the results of interviews, 19 people, or 61.29% of farmers, have used poor-quality seeds.

b. Planting and basic fertilizer application

Rainfall is significant in determining the success of potato farming. Potato plants ideally require rainfall of 1,000-1,300 mm/year during the growing period. The rainfall of Nagari Alahan Panjang in the last three years is 3,447, 4,645, 2,614 mm/year. This relatively high rainfall can increase the risk of disease attacks and crop failure. All sample farmers, or 100%, experience high rainfall risk.

c. Follow-up fertilization and hilling

Potato farmers in Nagari Alahan Panjang complain about the price of chemical fertilizers, which increases yearly. Farmers also find it challenging to get subsidized fertilizers, so they must spend more money to have the fertilizer. As a result, farmers will reduce the use of fertilizers, which can inhibit the growth of potato plants. Twenty-two potato farmers, or 70.97%, experienced a high fertilizer price.

d. Weeding

Potato farmers in Alahan Panjang generally have done weeding, but farmers cannot do weeding due to unfavourable weather, such as rain. In addition, it is also due to other factors, such as the laziness of farmers when it comes to Weeding. Farmers who do not practice proper Weeding are only three or 9.67% of farmers. Poor Weeding can reduce potato production because plants do not get maximum nutrients because they compete with weeds. In addition, wild plants can also be a home for pests and diseases that can attack potato plants, so potato plants become susceptible to pests and diseases.

e. Pest and plant disease control

Production risks can also come from pests and plant diseases. Pests that attack potato plants in Nagari Alahan Panjang are caterpillars, thrips, and pig pests. Caterpillar pests attack 30 or 96.77% of farmers. Caterpillars attack potato plants on the leaves and tubers. Thrips pests attack the leaves, which causes the leaves to wrinkle and dry to reduce potato tubers' growth. This pest attacks 17 farmers, or 54.84% of farmers. Meanwhile, pig pests attack five farmers or 16.13% of farmers. Pig pests attack potato plants by damaging plants and eating potato tubers.

Diseases that attack potato plants are fusarium wilt and Phytophthora. All farmers experienced the attack of Fusarium wilt. Fusarium wilt is caused by the fungus *Fusarium oxysporum*, which causes potato tubers to rot and causes the potato plants to wilt. The land where the plants were affected by fusarium wilt can no longer be planted because the disease remains in the soil—meanwhile, phytophthora disease attacks 31 or 100% of sample farmers. The fungus *Phytophthora Infestans* causes Phytophthora. This disease attack is characterized by blackish spots on the leaves, which cause the tubers to rot.

2. The Assessment of the Production Risk

Evaluation and risk assessment in potato farming is done using a risk map. Risk mapping is used to determine priorities when addressing risk sources. Before making a risk map, the frequency and impact values of the risk are first sought. Determination of the frequency and the magnitude of the effect refers to a previously determined scale. The frequency and impact of the risk are categorized as high if the value is above the average value. Conversely, the frequency and impact of the risk are classified as low if the value

is less than the average. Each risk's average frequency and impact values are entered into Table 4 below.

Table 4. The Assessment of Risk Production Source

Code	Source of Risk	Frequency	Category	Impact	Category
A	Seed Preparation				
A1	Low seed quality	1.21	Low	1.16	High
B	Planting and basic fertilizer application				
B1	High rainfall	1.84	High	1.52	High
C	Follow-up fertilization and hilling				
C1	Expensive fertilizer prices	1.77	High	1	Low
D	Weeding				
D1	Improper weeding	1.33	Low	1	Low
F	Pest and plant disease control				
F1	Caterpillar pest	2.13	High	1	Low
F2	Thrips pest	1.65	Low	1	Low
F3	Pig pest	2	High	1	Low
F4	Fusarium wilt disease	2.32	High	1.1	Low
F5	Phytophthora disease	1.45	Low	1.39	High
	Average	1.75		1.13	

The risk map is then drawn to show the position of each risk. The position of the risk source is arranged based on the risk frequency and impact values in Table 4. Figure 2 below is a risk map showing the location of each source of risk in potato production in Nagari Lahan Panjang, Solok Regency.

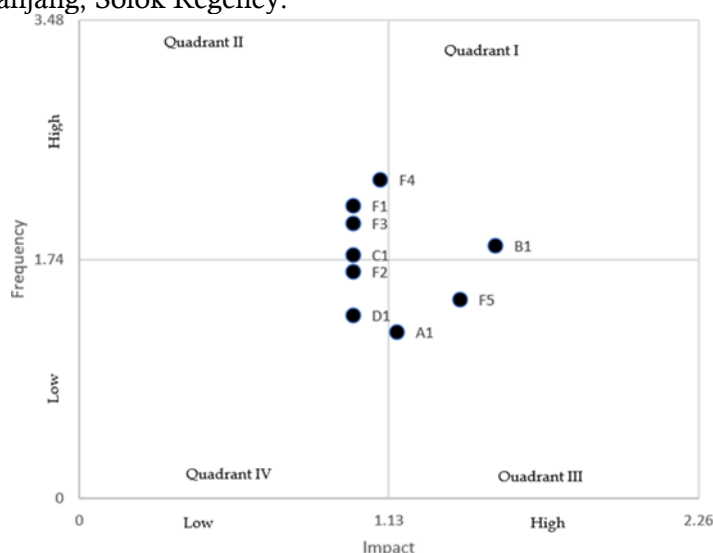


Figure 2. Production Risk Map of Potato Farming

The position of the risk source of potato farming in Nagari Alahan Panjang of Solok Regency is divided into four quadrants:

1. Quadrant I

Quadrant I is a quadrant with a high level of risk and impact. This quadrant is the main priority in managing risk sources for potato production in Nagari Alahan Panjang. Quadrant I has the most significant risk of influencing farming, so it must be prioritized. There is one source of risk in quadrant I, namely high rainfall (B1). Rainfall is an essential

factor that can affect the growth of potato plants. High rainfall can cause tubers to rot. Rainfall is a source of risk that cannot be controlled or reduced in frequency, making it difficult to overcome. Nagari Alahan Panjang has a reasonably high rainfall level, namely an average of 2,692 mm/year, and this condition does not match the ideal rainfall for potato plants, which should be 1,000-1,300 mm per year (BPTP, 2021).

2. Quadrant II

Quadrant II is a quadrant with a high frequency of occurrence but low impact. There are four sources of risk in quadrant II, namely high fertilizer prices (C1), caterpillar pests (F1), pig pests (F3), and fusarium wilt disease (F4). The high price of chemical fertilizers can affect farmers' ability to get fertilizers according to plant needs, affecting potato plants' growth. When chemical fertilizers are expensive, farmers overcome this by replacing chemical fertilizers with organic fertilizers. Farmers also reduce chemical fertilizer doses so it does not impact potato farming too much.

Caterpillar pests and pig pests are the pests that most often attack potato plants. Although they have a high frequency of occurrence, caterpillar pests are relatively easy for farmers to overcome, so the impact is not too significant. Caterpillar pests can be overcome by giving insecticides to plants. Meanwhile, pig pests attack potato plants by eating and damaging potato tubers. Pig pests do not significantly impact farmers because pigs only damage very few potato plants. Fusarium wilt disease is a disease that attacks potato plants, causing them to wilt and then die. Fusarium wilt disease also does not have a significant impact because it can be overcome by removing and then throwing away or burning plants attacked by fusarium wilt disease.

3. Quadrant III

Quadrant III is a quadrant with a low frequency of occurrence but a high impact. There are two risks in quadrant III: Low seed quality (A1) and phytophthora disease (F5). Poor-quality seeds can cause the plant to be easily attacked by pests and diseases. Poor-quality seeds are used at a low frequency because they do not occur in every planting season. Usually, farmers who experienced low yields during the previous harvest season will buy good seeds from outside the area. Although the occurrence frequency is low, using poor-quality seeds will impact crop failure.

Furthermore, another risk in quadrant III is phytophthora disease (F5). If phytophthora disease is not treated immediately, it will cause the disease to spread to other plants and have a significant impact on crop failure. The frequency of phytophthora disease attacks is low because they do not occur every planting season. Usually, phytophthora disease attacks a lot in the rainy season and at planting distances too close together.

4. Quadrant IV

Quadrant IV is a quadrant with a low frequency of occurrence and low impact. On the risk map, there are two sources of risk in quadrant IV: weeding that is not done correctly (D1) and thrips pests (F2). Weeding that is not done correctly can cause potato plants not to grow ideally. Wild plants around potato plants can seize potato plant nutrients. Farmers who do not weed properly are very few and have a low impact because farmers can overcome it by weeding properly. Thrips pests have a low frequency of occurrence because thrips usually attack during hot weather, and this Pest is relatively easy to overcome by spraying insecticides.

Risk Management of Potato Farming in Solok Regency

According to Kountur (2006:107), risk management can be done through 2 strategies: preventive and mitigation. A preventive strategy is a strategy to prevent or minimize the possibility of risk. A preventive strategy can be implemented to address risk sources in Quadrants I and II. In contrast, mitigation is a strategy to reduce the consequences of risk. Mitigation strategies can be applied in Quadrants I and III.

1. Preventive Strategy

a. Crop Diversification

Crop diversification is a farming practice of growing various crops on the same piece of land. Crop diversification can be achieved through crop rotation, intercropping, or

agroforestry methods. Its strategy aims to reduce the risk of crop failure and improve overall agricultural sustainability (FAO, 2020). By diversifying crops, it is expected that when one commodity experiences a loss, it can be compensated with profits from other commodities so that the loss is not too significant.

b. Crop Rotation

Crop rotation is an agricultural technique that involves planting various crop types in the same area over a sequence of growing seasons (FAO, 2020). Crop rotation is helpful to prevent the growth of pests and diseases that often attack one plant species. Rotating crops in potato farming is essential because potatoes cannot grow well if planted continuously. So, crop rotation could prevent pests and diseases from attacking plants, such as fusarium wilt.

c. More Effective Use of Organic Fertilizers

To overcome the high price of chemical fertilizer, farmers can use organic fertilizer as the main fertilizer in potato farming and only use chemical fertilizer as a supporting fertilizer.

2. Mitigation Strategy

a. Utilization of biological agent of *Trichoderma* sp.

Trichoderma is a biological agent that can eradicate fungi that cause phytophthora disease in the soil. *Trichoderma* is easily found in soil ecosystems and plant roots. *Trichoderma* can be propagated independently by farmers using rice as a medium to grow. *Trichoderma* is applied by sprinkling it on the root area and then watering it with sufficient water, or it can also be spread around the plant roots.

b. Implementing Weeding Properly

Weeding will reduce the possibility of slow tuber growth. Farmers in Nagari Alahan Panjang generally do the weeding. However, some farmers do not do weeding correctly because they are constrained by rainy weather or cannot do weeding because of specific activities and laziness. Weeding can reduce pest and disease attacks because wild plants or weeds can become nests for pests and diseases for potato plants.

c. Establishing partnerships with certified potato seed breeders

The limited availability of seeds can be solved by partnering with seed breeders from within and outside the region. Farmers should use good quality seeds to increase production. Farmers can partner with certified seed breeders because certified seeds have guaranteed quality standards. Farmers can form groups and partner with potato seed breeders to meet the need for potato seeds in each planting season.

The study identifies nine distinct sources of production risk highlights the complex interplay of environmental, biological, and economic factors inherent in agricultural production (Hardaker et al., 2015). The fact that high rainfall, fusarium wilt, and phytophthora disease are experienced by all farmers indicates these are systemic and pervasive threats to potato production in this region. The findings align with existing literature that identifies weather variability and plant diseases as major sources of production risk in agriculture globally (Glauber, 2013). The consistently high rainfall in Alahan Panjang, exceeding the ideal range for potato cultivation, directly contributes to the high incidence of fungal diseases like fusarium wilt and phytophthora, as excessive moisture creates favorable conditions for their proliferation.

The challenges related to seed preparation resonate with the broader issue of access to quality inputs in agriculture, particularly for smallholder farmers (Swinnen & Maertens, 2007). The limited number of local seed breeders forces farmers to rely on potentially more expensive and less reliable sources from outside the region or resort to using uncertified, low-quality seeds. The significant percentage of farmers using poor-quality seeds (61.29%) highlights a critical vulnerability, as poor-quality seeds can lead to lower yields and increased susceptibility to pests and diseases (FAO, 2020). This situation underscores the need for strengthening local seed production systems or facilitating access to certified seeds through farmer cooperatives or government initiatives.

The concern over high fertilizer prices mirrors a common challenge faced by farmers worldwide, particularly with the increasing cost of chemical inputs (Pretty, 2008). The difficulty in accessing subsidized fertilizers further exacerbates this economic risk, potentially leading to suboptimal nutrient application and reduced yields.

The risk assessment using a risk map provides a valuable tool for prioritizing risk management efforts (Kountur, 2006). The identification of high rainfall in Quadrant I (high frequency, high impact) correctly positions it as a primary concern requiring urgent attention. This aligns with the understanding that uncontrollable environmental factors with significant consequences demand robust mitigation strategies.

The placement of high fertilizer prices, caterpillar pests, pig pests, and fusarium wilt in Quadrant II (high frequency, low impact) suggests that while these risks occur often, farmers have developed (or perceive they have) relatively effective ways to manage their immediate impact. For instance, the study notes farmers' adaptation to high fertilizer prices by using organic alternatives or reducing doses, and their ability to control caterpillar and fusarium wilt through insecticide application and removal of infected plants, respectively. However, it's crucial to consider the long-term sustainability and potential hidden costs of these coping mechanisms. For example, reduced fertilizer use might impact long-term soil health, and reliance on chemical pesticides can have environmental consequences (Pretty, 2008).

Low seed quality and phytophthora disease falling into Quadrant III (low frequency, high impact) highlights risks that, while not occurring as frequently, can have severe consequences when they do. The reliance on poor-quality seeds, even if infrequent, can lead to significant yield losses, as the study points out. Similarly, a severe outbreak of phytophthora disease, if not managed promptly, can cause widespread crop failure, as also indicated in the study. This quadrant emphasizes the need for preparedness and effective mitigation strategies to minimize the potentially devastating effects of these less frequent but high-impact events.

Finally, improper weeding and thrips pests in Quadrant IV (low frequency, low impact) represent risks that are less pressing in the overall risk management prioritization for the region. However, it's important to note that even low-impact risks can contribute to reduced overall productivity and should not be entirely disregarded.

The study's proposed risk management strategies align well with the identified risks and the principles of preventive and mitigation approaches (Kountur, 2006). Preventive Strategies: Crop diversification and crop rotation directly address the systemic risks of high rainfall and the build-up of soil-borne diseases like fusarium wilt (FAO, 2020). By breaking monoculture patterns, these practices can enhance soil health, reduce disease pressure, and provide alternative income sources in case of potato crop failure.

More effective use of organic fertilizers offers a direct preventive measure against the economic risk of high chemical fertilizer prices while potentially improving soil health and reducing environmental impacts (Pretty, 2008).

The suggestion of establishing partnerships with certified potato seed breeders is a crucial preventive strategy to address the fundamental issue of low seed quality, ensuring farmers have access to reliable and disease-resistant planting material (FAO, 2010).

Meanwhile, Mitigation Strategies proposed in this study include: The utilization of the biological agent *Trichoderma* sp. offers a targeted mitigation strategy against the high-impact risk of phytophthora disease, providing an environmentally friendly alternative to chemical fungicides (Whipps, 2001). Implementing weeding properly serves as a basic but essential mitigation measure against potential yield losses and indirect impacts of weed infestation on pest and disease incidence.

While not explicitly listed as a mitigation strategy in the study's framework, the need for effective drainage systems to manage high rainfall, identified as a high-frequency, high-impact risk, would be a crucial mitigation measure to consider. Similarly, access to agricultural insurance could mitigate the financial impact of crop losses due to various production risks, including high rainfall and disease outbreaks (Glauber, 2013).

CONCLUSION

Nine production risks have been identified in potato farming in Solok Regency. These sources of risk are the use of poor-quality seeds, rainfall, expensive fertilizers, poor weeding, caterpillar pests, thrips pests, pig pests, fusarium wilt disease, and phytophthora disease.

Farmers in Nagari Alahan Panjang can manage risk through preventive and mitigation strategies. Farmers can implement preventive strategies such as crop diversification, crop rotation, and utilizing more organic fertilizers. Mitigation strategies include utilizing *Trichoderma* sp biological agents, weeding, and partnering with potato seed breeders.

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