Vol.23 No.1 February 2026: 148-162

SEPA

SEPA
Jurnal Sosial Ekonomi Pertanian dan Agribisnis
Program Studi Agribisnis Fakultas Pertanian
Universitas Sebelas Maret Surakarta
ISSN : 1829-9946 (Cetak) ISSN : 2654-6817 (Online)
Website: https://jurnal.uns.ac.id/sepa/

RISK PERCEPTION OF CHILI FARMERS IN CONTROLLING ANTHRACHNOSE DISEASE AS A FOCUS OF AGRICULTURAL EXTENSION IN RURAL JAVA

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Abstract. Environment and economic losses due to anthracnose disease attacks on chilli farming are inevitable, fostering farmers' risk perceptions. Unmanaged risks contribute to inappropriate disease control behaviors that ultimately harm farmers and environment. Risk reduction can be the focus of agricultural extension activities, to reduce losses at the farmer level. This study aims to discover how farmers' risk perceptions influence anthracnose disease control and to formulate relevant extension focuses. The research is conducted in three rural areas in Central Java and the Special Region of Yogyakarta: Purworejo Regency, Wonogiri Regency and Sleman Regency. The mixed-methods approach is carried out through observations on farmers' land and surveys using indicators of Good Horticultural Practices to explore disease control methods, perceptions of pesticide use and farmers' risk perceptions of disease control. The results show that unmanaged farmers' risk perceptions give rise to collective barriers among farmers. The context of locality and farmer institutions is a determinant of farmers' learning success. Primarily, efforts to reduce risk perception are urgent to be the focus of agricultural extension in rural areas. An extension service that orients farmers to their practices is the key to increasing the confidence of farmers in sustainable disease control.

Keywords: Agricultural extension, Anthracnose, Chilli, Disease control, Risk perception

Citation: Untari, D. W., Adisty, D. A. R., Sa'idah, T. N., Siwi, A. P. N., Khasanah, I. N., Pramudita, L. I. N., Handayani, H., Villamar, J. G., Laitae, C., Subejo, Akhda, N. T. (2026): risk perception of chili farmers in controlling anthrachnose disease as a focus of agricultural extension in rural java. SEPA (Jurnal Sosial Ekonomi Pertanian dan Agribisnis), 23 (1), 148-162. https://dx.doi.org/10.20961/sepa.v23i1.115396

INTRODUCTION

Chili is one of the main horticultural commodities on Java Island which faces serious challenges due to plant diseases, particularly anthracnose (*pathek*) caused by the fungus of *Colletotrichum* spp.

(Hartini, 2025). Economic losses resulting from disease attacks on chili reach 30–50% of total harvest yields (Kleruk et al., 2024). As the region with the largest chili production in Indonesia, climate change also affects fluctuations in farmers' production (Mirón et al., 2023). This uncertainty generates risk perceptions among farmers, which often become more complex due to climate variability (Kunreuther et al., 2014), placing farmers in a dilemma when making decisions (Scoones, 2024). Risk perception has the potential to become a focal point of agricultural extension in helping farmers manage the risk of yield loss caused by anthracnose. Based on this phenomenon, this study aims to examine farmers' risk perceptions in controlling anthracnose disease in order to formulate relevant extension priorities.

Risk perception (or perceived risk) refers to how individuals perceive or assess risk. People have different attitudes toward risk, leading them to respond to risky situations in diverse ways (Khanal et al., 2022). Intervention in the form of agricultural extension plays an important role in helping farmers understand the benefits of technology, reduce excessive risk perceptions, and strengthen social networks that support the adoption of agricultural innovations. Thus, farmers are expected to improve productivity and food security (John et al., 2023). In tropical countries such as Indonesia, climate challenges and disease pressures are higher than in temperate regions (Bajwa et al., 2020; Schneider et al., 2022). Therefore, effective and evidence-based agricultural extension is essential to equip farmers with mitigation strategies tailored to their local conditions.

Although numerous studies have examined anthracnose in chili in relation to pesticide use (Adiyoga et al., 2022; Allam et al., 2022; Rohsejati et al., 2025), most research has focused on the technical aspects of disease control (Hartini, 2025). Meanwhile, farmers' risk perception has been studied (Khanal et al., 2022; Adnan et al., 2023) however, no studies have integrated these two aspects, anthracnose and risk perception. Furthermore, farmers' risk perception in relation to disease control practices and its implications for evidence based extension priorities, particularly in chili production centers on Java, remains underexplored. The study contributes to the literature by enriching understanding of the relationships among risk perception, pesticide use behavior, and the adoption of integrated pest management in tropical agricultural systems vulnerable to climate and disease pressures. Practically, the research provides an empirical basis for agricultural extension agents and policymakers to design more targeted extension priorities which are adaptive to the local condition of the farmers.

This study explores how disease attack risk perception can become a theme for agricultural extension. It examines farmers' disease control methods, perceptions of pesticide use, and perceptions of risk related to disease control. Farmers' anthracnose control practices are mapped to assess whether they understand and apply Integrated Pest Management (IPM), as the combination of methods determines sustainable crop protection (Zhou et al., 2024). The application of chemical pesticides in Indonesia is practiced by the majority of farmers because it is considered effective and easy to use (Wisnujati et al., 2021). Perceptions of pesticide use provide insight into the types, dosages, and timing of pesticide applications. Furthermore, risk perception related to disease control analyzes farmers' responses to risks arising from the disease itself and from information unclarity in controlling the disease.

This research adopts case studies in the chili producing location of Purworejo, Wonogiri, and Sleman Regencies. The findings indicate that individual farmers' risk perceptions create shared barriers within farmer communities, making social and institutional contexts key determinants of successful farmer learning process. Efforts to reduce risk perception as part of extension priorities can be pursued through collective learning approaches. Specifically, this study provides evidence to inform policymakers and support evidence based policy development.

METHOD

The research adopted case studies in the chili producing of Purworejo, Wonogiri and Sleman Regencies. Chili was the highest production horticultural commodity in the three regencies. Curly chili was only grown in Purworejo Regency, while large chili and cayenne pepper were parked in all three districts. Cayenne pepper was grown on a large scale in all three regions. In 2024, cayenne pepper production in Sleman Regency was 105,845.28 quintals, followed by Wonogiri and Purworejo Regencies of 25,599.48 quintals and 5,961.83 quintals (Statistics of each regency, 2025). The magnitude of this production scale was accompanied by the attack of anthracnose disease detrimental to farmers. Farmers' risk perception of the disease attacks contributes as a basis for the formulation of the focus of agricultural extension in areas that have similar characteristics.

This study employed a descriptive research design with a mixed-methods approach which combine both quantitative and qualitative methods to examine farmers' risk perceptions. The mixed-methods approach was implemented not only by collecting data from multiple sources but also by integrating both types of data to obtain a comprehensive understanding of rural agricultural activities in managing anthracnose risk in chili cultivation. This approach enables the researcher to address the limitations of a single method so that a clearer picture of the phenomenon under study is obtained. Qualitatively, data were collected by exploring farmers' practices (practice approach) through field observations and interviews regarding disease control activities. Quantitatively, data were obtained from 40 farmers, consisting of 26 men and 14 women. Participants were selected purposively, namely farmers cultivating chili on coastal land, riverbank areas along the river basin, and volcanic slopes (Mount Merapi). Data from both approaches were integrated to provide an empirical basis for agricultural extension agents and policymakers to design more targeted extension strategies which adaptive to the local conditions.

Data collection followed a practice-based approach through observation and interviews. Observations were conducted by visiting farmers' fields across the three study areas to identify disease types, their impacts on crop conditions, and the methods used by farmers to prevent and control them. Interviews were then conducted to explore farming activities and disease management practices in chili cultivation. Interview indicators refer to the Guidelines for the Implementation of Good Agricultural Practices (GAP) for Horticulture under Ministry of Agriculture Regulation No. 22 of 2021 on Good Horticultural Practices, covering: (1) land management, (2) seed management, (3) soil and/or growing media management, (4) fertilizer and/or other additive management, (5) water use, (6) chemical and/or pesticide use, and (7) harvesting. These seven components represent the core elements of horticultural practices and serve as a reference for assessing farmers' cultivation behavior.

Data analysis was conducted through the tabulation of both quantitative and qualitative data. The data were categorized according to variables relevant to risk perception: (a) disease control methods, (b) perceptions of pesticide use, and (c) farmers' risk perceptions regarding disease control. Variables (a) and (b) were binary variables measured by assigning a weight of 1 for responses indicating knowledge (knowing) or action (implementing) and 0 for responses indicating lack of knowledge or non-implementation for each item. Variable (c), farmers' risk perception of disease control, was measured by assigning a value of 1 to the selected response among five options namely no risk, low risk, moderate risk, risky, and very risky; while other responses were assigned a value of 0. Farmers' responses were then compiled into cross-tabulation tables for each variable. Qualitative data were analyzed according to the same variables. Qualitative information reflecting frequency or timing of implementation (variable a), reasons for implementation (variables a and b), and types of risk and risk perceptions (variable c) were summarized in cross-tabulations to provide contextual understanding of how farmers interpret practices and form perceptions. Finally, the two datasets were integrated to obtain a comprehensive understanding of farmers' risk perceptions of anthracnose and to assess their relevance as a focus for agricultural extension activities.

RESULT AND DISCUSSION

Disease Control Methods by Farmers

Disease control methods is one of a critical component in achieving both optimal and sustainable agricultural production. Effective disease management can reduce yield losses, maintain crop health, and minimize environmental impacts (Ratu et al., 2021). Within the integrated disease control management concept, plant diseases are tolerated but at levels below the economic threshold, allowing farmers to rely on routine monitoring and natural enemies, while chemical control is applied only when the risk of loss increases (Savary et al., 2019). Table 1 indicates that the majority of farmers understand and implement Integrated Pest Management (IPM) and Integrated Disease Management (IDM) in cultivation practices. The combination of biological, physical, and chemical control methods forms the foundation of sustainable crop protection (Zhou et al., 2024). This implementation demonstrates the effectiveness of extension activities in transforming theoretical knowledge into practical field actions, such as plot monitoring, pesticide application, crop rotation, and field sanitation, and other actions.

Anthracnose is one of the diseases that frequently attacks chili plants. When infestations severe, farmers apply chemical pesticides. Although farmers are aware of alternatives such as botanical pesticides and barrier crops, they perceive botanical pesticides as less effective. This behavior reflects farmers' decision-making processes in comparing alternative methods to assess profitability and risk (Murray-Watson et al., 2022). Extension support is significant to enhance farmers' adoption of botanical-based technologies (Barokah & Jannah, 2025; Yao et al., 2023).

Table 1. Disease control methods

Statement	Do you know?		Do you implement?	
	Know	Do not know	Implement	Rather not to answer
Monitor each plot to detect pests and diseases	**95%**	5%	**90%**	8%
Chemical pesticides	**100%**	0%	**90%**	10%
Botanical pesticides	**90%**	10%	45%	**55%**
Biopesticides	**100%**	0%	**63%**	38%
Use non-pesticide and non-biopesticide substances	**100%**	0%	**83%**	18%
Crop rotation	**88%**	5%	**63%**	30%
Field sanitation	**93%**	5%	**93%**	5%
Plant barrier crops	**78%**	23%	33%	**65%**
Use protective equipment	**93%**	5%	23%	**75%**
Use pest traps	**98%**	3%	**78%**	23%
Use plastic or dry straw mulch	**93%**	8%	**78%**	23%
Cut and destroy infected plant parts or cut and remove diseased plants	**95%**	3%	**88%**	10%

Source: Data Processed, 2025

Note: Percentages in bold indicate the highest values

Table 2. Frequency and reasons for implementing disease control methods

Method	Frequency/Timing of Implementation	Reasons
Monitor each plot to detect disease	• Daily • 10 days after planting	**Reasons for implementation:** • To determine plant conditions

Method	Frequency/Timing of Implementation	Reasons
	• Every 1–2 days • Three times a week • Every 2–3 days • After planting	• As a preventive measure • To achieve optimal production • Basis of appropriate control actions **Reasons for non-implementation:** (none)
Chemical pesticides (synthetic substances with rapid and strong effects in killing diseases), including insecticides, fungicides, rodenticides, molluscicides, nematicides, and acaricides	• Twice a week • After applying botanical pesticides • When symptoms appear • 7–10 days after planting • Vegetative stage • 14 days after planting • Once a week • 2–3 times a week	**Reasons for implementation:** • Provide faster results • Prevent and control plant disease attacks • More cost-efficient • Increase harvest quantity **Reasons for non-implementation:**(none)
Botanical pesticides (chemical compounds extracted from plants such as tobacco, lemongrass, neem, papaya, soursop, and garlic)	• When pests and diseases occur • Every 15 days • Once a week • Before planting • 4–5 days after planting • 14 days after planting	**Reasons for implementation**: • More cost-efficient • Prevent plant disease attacks • Improve nutrition and soil fertility **Reasons for non-implementation**: • Results are relatively slower • Less practical to apply • Perceived as less effective
Biopesticides (active ingredients derived from living organisms such as bacteria, fungi, viruses, or their extracts; e.g., Bacillus thuringiensis, Trichoderma, Beauveria)	• Before infestation • During infestation • Once a week • Every 15 days • During land preparation • After chemical pesticide application • Twice a week • Every two weeks	**Reasons for implementation:** • Increase disease resistance • Has been applied before • As additional treatment • Strengthen root systems • More cost-efficient • Reduce the risk of crop failure • Accelerate decomposition of organic matter • Inhibit pathogenic fungi • Neutralize manure content **Reasons for non-implementation:** • Limited knowledge of application
Use of non-pesticide and non-biopesticide substances such as calcium carbonate (dolomite/lime)	• During land preparation	**Reasons for implementation:** • Neutralize soil condition • Prevent pathogenic fungal growth • Improve and stabilize soil pH • Reduce soil moisture **Reasons for non-implementation:** (none)
Crop rotation	• After harvest • Every 2–3 months • Every 3–7 months • At crop replacement	**Reasons for implementation:** • Support economic cycle • Follow other farmers' practices • Improve soil fertility • Avoid plant disease attacks **Reasons for non-implementation:** (none)
Field sanitation (cleaning of infected plants)	• After disease occurrence • After harvest • At planting	**Reasons for implementation:** • Prevent disease transmission • Avoid potential losses • Reduce humidity of environment **Reasons for non-implementation:** (none)

Method	Frequency/Timing of Implementation	Reasons
Planting barrier crops (e.g., refugia plants, cosmos, hibiscus)	• At planting • At early fruiting • During flowering • Before the branch splitting	**Reasons for implementation:** • Avoiding disease attacks • Reduce wind exposure • Protecting crops from disease **Reasons for non-implementation:** • Lack of interest in explanation • Perceived as less effective • Perceived as impractical • Negative feedback from other farmers
Use of protective measures such as nets	• Before fruiting • At planting • During grain filling of rice crops • During rainy periods	**Reasons for implementation:** • Prevent disease attacks **Reasons for non-implementation:** • Requires relatively high capital
Use of disease traps (e.g., sticky traps, light traps)	• After infestation • At early flowering • At planting	**Reasons for implementation:** • Reduce disease intensity **Reasons for non-implementation:** (none)
Use of plastic or dry straw mulch to cover soil	• At planting • During land preparation • After bedding formation	**Reasons for implementation:** • Suppress weed growth • Maintain soil moisture • Prevent nutrient loss from fertilizer • Reduce soil erosion risk **Reasons for non-implementation:** (none)
Cut and destroy infected parts or uproot diseased plants	• When infected • At 10–20 days of plant age • When early symptoms appear (e.g., leaf curling)	**Reasons for implementation:** • Prevent transmission to other plants **Reasons for non-implementation:** (none)

Source: Data Processed, 2025

Based on Tables 1 and 2, monitoring each plot to detect disease is a widely implemented practice (90%). Routine monitoring is carried out to enable early detection of field emergencies such as pest and disease outbreaks as well as nutrient deficiencies (Agelli et al., 2024). Pesticide use can increase yields by minimizing damage caused by disease attacks (Issaka et al., 2023). Although all farmers are aware of biopesticide use, only 63% actually apply it. Biopesticides are used in various ways, before or after disease outbreaks, to enhance plant resistance as well as strengthen root systems. This is consistent with Yao et al. (2023), who reported that biological fungi improve nutrient-use efficiency and reduce pollution from agricultural chemicals. Conversely, some farmers do not use biopesticides because they perceive them as less practical and lack sufficient knowledge about the application.

All farmers are aware of the use of non-pesticide and non-biopesticide substances, yet only 83% implement them. Dolomite is commonly applied during land preparation to neutralize soil pH, prevent pathogenic fungal growth, and reduce soil moisture levels, while biopesticides are used to optimize pest and disease control (Fenibo & Matambo, 2025). Although 88% of farmers are aware of crop rotation, only 63% practice it. Implementation timing varies, such as after harvest or every two to three months, motivated by economic turnover, imitation of other farmers' practices, improvement of soil fertility, and disease evasion. Some farmers have not adopted this practice due to limited understanding of appropriate rotation patterns. In fact, crop rotation improves soil fertility by increasing soil nitrogen, enhancing soil structure, and helping suppress pest and disease cycles (Harefa et al., 2025).

The majority of farmers (93%) are aware of and implement field sanitation practices, conducted after disease occurrence, after harvest, and at the beginning of planting to prevent disease transmission, avoid potential losses, and reduce the risk of excessive field moisture. The finding is consistent with the concept of sanitation as a cultural control practice that emphasizes the removal and destruction of infected plant parts or residues to prevent the spread of pests and diseases across growing seasons (Zhou et al., 2024).

Approximately 78% of farmers are aware of the benefits of planting barrier crops, yet only 33% implement the practice. Application typically occurs at planting, during fruiting, or prior to branch splitting, although some farmers perceive the practice as inconvenient. In reality, the effectiveness of barrier crops depends on environmental conditions and cultivation practices, and under certain circumstances the method may not function optimally (Sarma, 2022). Similarly, the adoption of protective methods using nets remains low (23%) despite high awareness, mainly due to high capital requirements (Murtiningsih et al., 2023). Farmers cited economic constraints, particularly the high investment costs of netting infrastructure.

Most farmers (98%) are aware of disease traps, but fewer implement it. The traps are typically applied when disease attacks occur or when plants begin flowering to reduce disease intensity. Moreover, soil covering using plastic or dry straw mulch is also widely known and practiced (93% and 78%, respectively). Ninety five percent of farmers are aware of cutting and destroying infected plant parts or uprooting diseased plants, yet the level of practice is lower. This method is applied at different times, such as when anthracnose symptoms appear, at 10–20 days after planting, or when early symptoms such as leaf curling occur. Farmers recognize that the implementation of this method helps prevent transmission to other plants.

Overall, farmers demonstrate high levels of knowledge regarding various anthracnose control methods. However, the implementation remains relatively low for several practices, including botanical pesticides, biopesticides, crop rotation, barrier crops, and protective netting. Limited adoption is driven by perceptions of slower effectiveness, lower practicality, and insufficient technical knowledge. In general, farmers prefer methods that provide rapid, simple, and cost-efficient results, even though they may pose environmental risks. Therefore, extension support through face-to-face interactions, farmer field schools, and improved access to information is needed to strengthen farmers' capacities (Astari et al., 2023). These findings underscore that agricultural extension should not only focus on knowledge enhancement but also on technical assistance and skills development.

Perceptions of Pesticide Use

Farmers have diverse considerations, ranging from personal experience to perceptions of the risk of crop failure. Perception is the process by which individuals select and interpret environmental stimuli, influencing their behavior and decision-making (Parhanudin et al., 2025). Perception can be examined through observing the relative advantage, compatibility, complexity, trialability, and observability (Burrahmad et al., 2020). In this study, however, perception is associated with risks to health and the environment. Farmers' perceptions regarding pesticide use determine the type, dosage, and timing of application. The perception that chemical pesticides are the most effective method may lead to dependency, making the role of agricultural extension agents crucial in improving knowledge, reshaping mindsets and behaviors, and delivering appropriate information (Sofia et al., 2022). Therefore, extension services are essential in shaping farmers' perceptions toward disease prevention.

Based on Tables 3 and 4, 90% of farmers use chemical pesticides because they are perceived to deliver effective results in controlling anthracnose disease. Farmers' risk perceptions tend to prioritize short-term benefits over potential health and environmental risks. Notably, 45% of farmers apply chemical pesticides at doses exceeding recommended levels, moreover during severe disease outbreaks.

Nevertheless, some farmers adhere to recommended dosages due to concerns about triggering pesticide resistance.

Table 3. Farmer's perceptions of pesticide use

Statement	Do you know?		Do you implement?		
	Know	Do not know	Yes	No	Rather not to answer
Use chemical pesticides	**100%**	0%	**90%**	10%	0%
Apply pesticides exceeding the recommended dosage	**85%**	15%	45%	**55%**	5%
Apply pesticides to food crops	**88%**	5%	**78%**	15%	7%
Apply pesticides after 10 days after planting and continue periodically until 70–95 days after planting	**93%**	8%	**68%**	32%	0%
Observe the safe interval between the last pesticide application and harvest	**98%**	3%	**85%**	15%	0%
Aware of the dangers of pesticides to animals and wildlife	**95%**	5%	**75%**	25%	0%
Keep livestock away from areas treated with pesticides	**98%**	8%	**60%**	38%	2%
Keep livestock away from pesticide-contaminated water sources for at least 14 days	**88%**	10%	**50%**	48%	2%
Not to contaminate water bodies with pesticide waste or containers	**85%**	10%	**78%**	15%	7%
Not to dispose of pesticide container wash water into water bodies	**90%**	8%	**60%**	35%	5%
Aware that continuous pesticide use causes environmental pollution	**98%**	3%	**68%**	30%	2%

Source: Data Processed, 2025

Note: Percentages in bold indicate the highest values

Table 4. Farmer's perceptions of pesticide use

Statement	Reasons
Use chemical pesticides	**Reason for implementation:** To fasten the control of anthracnose disease effectively
Apply pesticides exceeding the recommended dosage	**Reasons for implementation:** - To accelerate the effectiveness of control responses. - Disease incidence has exceeded the economic threshold. - To optimize the efficiency of pesticide use. - To comply with applicable regulations and guidelines. - To adjust application according to crop conditions. - To reduce the risk of poisoning **Reasons for non-implementation:** - Risk of pesticide resistance
Apply pesticides to food crops	**Reasons for implementation:** - Crops are affected by disease. - High control effectiveness. - Pesticide application aims to suppress disease from spreading.

Statement	Reasons
Apply pesticides after 10 days after Planting and continue periodically until 70–95 days after planting	**Reasons for implementation:** To prevent the occurrence of plant disease attacks.
Observe the safe interval between the last pesticide application and harvest	**Reasons for implementation:** - To enhance pesticide absorption efficiency by plants - To minimize the risk of poisoning - To comply with regulations - To reduce pesticide residues in consumed products
Aware of the dangers of pesticides to animals and wildlife	**Reasons for implementation:** Potentially causing toxicity effects **Reasons for non-implementation:** - No livestock are raised around the cultivation area - Effects depend on the type, active ingredient, and formulation of the pesticide
Keep livestock away from areas treated with pesticides	**Reasons for implementation:** - To minimize the risk of poisoning. - Livestock are confined in cages during the period of pesticide application. - Livestock are kept away from fields to minimize poisoning risk.
Keep livestock away from pesticide-contaminated water sources for at least 14 days	**Reasons for implementation:** Pesticide spraying is conducted far from livestock areas **Reasons for non-implementation:** - Livestock drinking water is sourced from wells.. - Farmers do not raise livestock.
Not to contaminate water bodies with pesticide waste or containers	**Reasons for implementation:** - Special facilities for pesticide waste disposal are available. - Used pesticide containers are collected and resold. - Used pesticide containers are disposed of through controlled burial. - To ensure environmental safety and sustainability.
Not to dispose of pesticide container washing water into water bodies	**Reasons for implementation:** - To prevent water pollution **Reasons for non-implementation:** - Pesticide container washing water is disposed of directly in the field. - Pesticide container washing water is disposed of far from water sources.
Aware that continuous pesticide use causes environmental pollution	**Reasons for implementation:** - Forced by necessity to maintain crop yields. - Chemical pesticides provide relatively rapid control results. **Reasons for non-implementation:** - Considering the environmental sustainability. - Pesticides are used according to recommended dosages.

Source: Data Processed, 2025

Based on Table 3 and 4, approximately 88% of farmers are aware of, and 78% implement, the pesticide use on food crops. The high prevalence of chemical pesticide use is driven by the expectation of optimal and rapidly seen results. In addition, chemical pesticides are the most widely used means of controlling plant pests and diseases in Indonesia (reaching 95.25%) because they are considered effective, easy to use, and economically beneficial (Wisnujati et al., 2021). However, the use of chemical pesticides on food crops should be accompanied by extension efforts to improve knowledge of proper pesticide use. Although the majority of farmers (90%) know that pesticide use on food crops should follow recommended dosages, only 70% apply this in practice. This phenomenon indicates a dilemma between food safety and economic necessity among farmers.

In using chemical pesticides, most farmers understand the recommended timing of application (93%), yet implementation is not always consistent (68%). Farmers generally apply pesticides after 10 days after planting and continue periodically until 70–95 days after planting to prevent anthracnose attacks. However, 33% of farmers adjust applications according to field conditions. According to Sarma (2022), farmers' pesticide use decisions are also influenced by their immediate social environment, such as family members, farmer groups, and neighbors. Thus, perceptions of pesticide application timing are situational and shaped by farmers' experience. In addition to timing rules, farmers are also aware of the pre-harvest interval between the last pesticide application and harvest (98%), although only 85% comply. This suggests that farmers recognize the risk of residues in harvested products but still choose to use pesticides to avoid yield losses.

From an environmental risk perspective, 95% of farmers understand that pesticides are harmful to animals or can cause poisoning; consequently, 88% apply pesticides away from animals. Farmers keep their livestock away from treated fields to prevent poisoning and potential mortality. In addition, 88% of farmers are aware that livestock should be kept away from water bodies treated with pesticides for at least 14 days. To prevent ecosystem damage, 85% of farmers have knowledge of pesticide waste management and 78% implement it to safeguard environmental safety, particularly in aquatic areas. Farmers are also aware (90%) of safe pesticide waste disposal, although only 60% practice it, leaving 35% who do not implement the safe pesticide waste disposal. According to Yami et al. (2025), some farmers in Nigeria dispose of pesticide containers in water bodies, burn them, or bury them due to limited awareness and lack of training on proper pesticide use and disposal, as well as the lack of designated disposal facilities. In response of that situation, extension and training are needed to improve farmers' knowledge and behavior regarding pesticide waste management.

As many as 98% of farmers know that continuous pesticide use can pollute the environment. Nevertheless, 68% still practice it to obtain faster visible results and secure harvests, similar to many farmers in Africa who use chemical pesticides while overlooking consumer and environmental safety risks to avoid post-harvest losses (Anaduaka et al., 2023). However, 30% of farmers use pesticides only as needed to maintain environmental sustainability. This phenomenon indicates that farmers' risk perceptions emphasize immediate benefits over the potential long-term hazards of chemical pesticides.

Farmers in this study have knowledge of appropriate pesticide use according to recommended dosages and efforts to minimize impacts on the environment as well as non-target organisms. This finding contrasts with the finding of Pan et al. (2020), which showed that most farmers' awareness of pesticide impacts was limited to food quality and human health. The result of this study indicates that pesticide use practices are increasingly aligned with technical guidelines, consistent with the high level of farmers' knowledge regarding proper pesticide application. The implementation of knowledge-based policies through strengthened extension services is essential to improve pesticide use safety among farmers (Uikey et al., 2025). Therefore, expanding farmers' understanding of pesticide risks through agricultural extension is crucial to reduce its undesired negative effects particularly its toxicity, dosage accuracy, and environmental impacts.

Risk perception refers to an individual's subjective assessment of the characteristics and severity of a particular risk. Khanal et al. (2022) define risk perception as an individual's expectation of potential loss; individual having the greater the expected loss, the higher the level of risk perceived by the individual. Farmer's own experiences and knowledge will shape their risk perceptions, which ultimately influence their decisions regarding technology adoption.

Based on Tables 5 and 6, farmers often encounter several challenges in facing risks related to anthracnose disease control and pesticide use. First, 87.5% of farmers report experiencing crop losses due to disease, resulting in production decreases and economic losses. Consistent with Damayanti et al. (2023), farmers tend to increase pesticide use when chili farming faces severe pest and disease attacks. To mitigate environmental losses, a study in Europe found that national governments should provide financial support to farmers to manage risks associated with plant viruses, ensure timely risk identification, and implement effective characterization practices to reduce virus spread in the food crop sector (Hilaire et al., 2022). Such policies could be adapted in Indonesia to provide financial assistance and strengthen risk awareness in disease control efforts to promote sustainable agriculture.

Second, 60% of farmers state that the risk of crop loss increases when they do not purchase pesticides. In line with Adiyoga et al. (2022), affordability and ease of access to pesticide products are important factors influencing farmers' decisions regarding product selection. Despite the high cost of pesticides, farmers continue to purchase them to avoid greater losses. Farmers with limited capital still tend to buy pesticides but opt for more affordable pesticide products.

Risk Perceptions of Disease Control

Table 5. Risk perception toward anthracnose disease control

Type of Risk	Percentage				
	Not Risky	Less Risky	Quite Risky	Risky	Very Risky
Harvest loss	0.0%	0.0%	5.0%	7.5%	**87.5%**
Cost of disease control	2.5%	0.0%	10.0%	27.5%	**60.0%**
Health impacts	2.5%	12.5%	7.5%	25.0%	**52.5%**
Environmental impacts	2.5%	5.0%	25.0%	27.5%	**40.0%**
Failure of non-chemical methods	7.5%	12.5%	17.5%	**40.0%**	22.5%
Lack of information	5.0%	22.5%	12.5%	**40.0%**	20.0%

Source: Data Processed, 2025

Note: Percentages in bold indicate the highest values

Table 6. Risk perception toward anthracnose disease control

Type of Risk	Farmer's Risk Perceptions
Harvest loss (caused by disease) Not applying pesticides can risk harvest loss.	- Decrease in yields, even harvest failure - Economic loss - Crop damage - Diseases become more difficult to control
High Disease Control Costs Pesticides are expensive, but not purchasing pesticides can increase the risk of harvest loss	- Farmers need to continue spraying - Depends on capital availability - Continue purchasing pesticides, with more affordable prices
Health Impacts (Pesticides) Pesticide use can pose health risks.	- Farmers have experienced accidental pesticide exposure due to inhalation from the wind drift - Most farmers use Personal Protective Equipment (PPE) or masks because they understand the longterm risks of pesticide exposure
Environmental Impacts (Pesticides) Pesticides can risk environmental damage and the loss of natural enemies.	Natural enemy populations decrease after spraying activities
Failure of Non-Chemical Methods Using natural pesticides risks harvest failure.	- Natural pesticides are considered effective but require a relatively longer time to work. - Effectiveness depends on the type of disease. - Never used these pesticides before.

Type of Risk	Farmer's Risk Perceptions
Lack of Accurate Information Information on disease control is conflicting and risks harvest loss.	- Information obtained is inconsistent. - Confirming information with other farmers. - Information from the YouTube platform comes from individuals with practical experience. - A selection and evaluation process is required for the obtained information.

Source: Data Processed, 2025

Third, pesticide use has implications for human health and the environment. A total of 52.5% of farmers perceive pesticide application as highly risky to health, and 40% perceive environmental impacts. These perceptions are based on experiences of accidental exposure, such as inhalation during spraying due to wind drift. The improper use of pesticides, particularly exceeding recommended dosages, can have negative effects on the environment, farmers' health, and consumers (Zohoungbogbo et al., 2024). Reported health impacts include skin rashes, eye irritation, and respiratory disorders (Thapa et al., 2024). Consequently, most farmers use personal protective equipment (PPE) because they recognize the long-term risks of pesticide exposure. Thus, it is necessary to strengthen knowledge about the environmental impacts of pesticides.

Fourth, 40% of farmers perceive the use of natural or non-chemical pesticides as posing a risk to crop yields. The risk of yield loss is associated with the perception that natural pesticide act more slowly than chemical one. A study on Good Agricultural Practices (GAP) indicates that perceived benefits enhance farmers' innovative behavior (Firdaus et al., 2024). When a practice is not perceived to generate clear benefits, farmers are less likely to adopt it. This finding suggests that perceptions of speed and effectiveness in controlling the disease are key factors underlying the low adoption of natural pesticides among farmers.

Fifth, 40% of farmers state that a lack of accurate information regarding anthracnose disease control increases the risk of yield loss. This is consistent with Fan et al. (2015), who found that insufficient farmer knowledge can lead to improper pesticide use behavior. This condition encourages some farmers to actively seek more accurate information, either by consulting fellow farmers, utilizing online media such as YouTube, or independently filtering available information.

Overall, farmers have the perception that they will experience crop losses, increased production costs, adverse health effects, and environmental damage. They also report that the information they receive is often inconsistent. Addressing these issues through knowledge dissemination, field demonstrations, and showcasing successful technologies via agricultural extension can help transform perceived risks into manageable risks. Enhancing farmers' preparedness in dealing with disease outbreaks such as anthracnose is expected to increase opportunities for improving chili production.

CONCLUSION

This study aimed to examine chili farmers' risk perceptions in controlling anthracnose disease and to formulate relevant priorities for agricultural extension in rural Java. The results indicate that farmers generally possess good knowledge of various disease control practices; however, the adoption of environmentally friendly methods such as botanical pesticides, biopesticides, crop rotation, and barrier crops remains relatively limited. Farmers' risk perceptions—particularly concerns over harvest losses, high disease control costs, and uncertainty regarding the effectiveness of non-chemical methods—encourage continued reliance on chemical pesticides as a rapid and practical solution.

The findings also reveal that risk perception functions not only as an individual cognitive factor but also as a collective barrier within farmer communities in adopting sustainable disease control technologies. Therefore, agricultural extension should prioritize strategies that reduce uncertainty through participatory learning approaches, demonstration activities, and strengthened farmer groups as collective learning platforms. Strengthening extension services, improving access to reliable information, and promoting field-based training are essential to enhance farmers' confidence in sustainable disease control practices while minimizing environmental and health risks in chili farming systems.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Lecturer–Student Collaborative Grant (No 3450/UN1/FPN/KU/KU.02.05/2025) and 2025 Flagship Research Grant of the Department of Agricultural Socio-Economics, both from the Faculty of Agriculture, University of Gadjah Mada.

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