Relationship between agronomical practices and fusarium basal rot disease of shallots in Karo and Samosir Regencies North Sumatera

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ABSTRACT

Fusarium basal rot is one of the major factors inhibiting shallot production caused by infection of the Fusarium oxysporum f.sp. cepae. Agronomical practices by farmers are considered important aspects influencing the incidence of this disease. The aimed of this study was to determine the incidence Fusarium basal rot of shallot in Karo and Samosir Regencies, North Sumatera, and to determine the relationship between disease incidence of Fusarium basal rot and agronomical practices of local farmers of shallot. This research was conducted in Payung and Pangambaten Villages, Karo Regency, and in Cinta Dame and Sait Nihuta Villages, Samosir Regency, North Sumatera. The methods employed included visual observation of disease symptoms and characteristics of disease signs of Fusarium basal rot of shallot. Subsequently, the incidence rate of basal rot disease was calculated at research location. Data agronomical practices of shallot were collected from shallot farmer respondents at the research sites using a survey method. The relationship between incidence of Fusarium basal rot disease data and agronomical practices of shallot data was analyzed using chi-square tabulation analysis. The results showed that disease incidence in both regions was relatively low, with an average occurrence of approximately 4.5%. Based on chi-square tabulation analysis, cultivation practices of shallot such as the use of resistant varieties of shallots, plastic mulch, crop rotation, and organic fertilizers were significantly associated with the low disease incidence of fusarium basal rot disease. Therefore, the use resistant varieties of shallot, polyculture planting patterns, plastic mulch, and organic fertilizers in shallot cultivation practices are recommended to prevent the incidence of Fusarium basal rot disease of shallot.

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1. INTRODUCTION

Shallot (Allium cepa L. group aggregatum) is an important horticultural bulb crop widely cultivated in Indonesia due to its high economic value and essential role in daily cuisine. As one of the leading horticultural commodities, shallots are intensively cultivated, particularly in the provinces of Central Java, East Java, West Java, and West Nusa Tenggara, which represent the main national production centers. In addition to their economic importance, shallots are also recognized for their nutritional and functional properties, including antioxidant and anti-inflammatory activities, and as sources of fiber, vitamin C, potassium, and folic acid (El Mashad et al. 2019; Syawal et al. 2019).

North Sumatra Province ranks seventh as the largest shallot producer in Indonesia, with a total production of 58,069 tons in 2024 from a harvested area of 3,861 hectares (BPS, 2025). The shallot production in North Sumatra has not yet met the local demand, so the supply of shallots in North Sumatra still relies on national production centers. Several production-limiting factors have been reported in North Sumatra. Shallot production in Karo Regency has declined due to several agronomic factors, such as moderate soil fertility and relatively high rainfall. Meanwhile, in Samosir Regency, pest and disease attacks, extreme weather conditions, declining land quality, limited availability of superior seeds, and restricted access for farmers to fertilizers and pesticides are the main challenges faced by farmers (Jabat *et al* 2025; Razali *et al* 2023; Fitri *et al* 2023).

The North Sumatra regional government continues to strive to achieve shallot self-sufficiency by increasing production through the prevention and control of pests and plant diseases. One of the main diseases affecting shallots is Fusarium basal rot, commonly known as moler disease. The disease incidence of Fusarium basal rot disease in shallots in North Sumatra has not yet been officially reported, particularly in Karo and Samosir Regencies.

Fusarium basal rot disease is primarily caused by infection with the *Fusarium oxysporum* f.sp. *cepae* (Le et al. 2020; Muthukumar et al. 2022; Vetrova et al. 2024), but several studies have reported interactions with other pathogens including *F. oxysporum*, *F. solani*, *F. tricinctum*, *F. proliferatum*, *F. rodelens*, *F. acutatum, F. anthophilium, F. annulatum* and *F. acuminatum* (Marianah et al. 2024; Haapalainen et al. 2016; Kalman et al. 2020; Vetrova et al. 2024). Fusarium basal rot also known as moler disease of shallots, was first discovered in Indonesia in Brebes Regency in 1997. Since then, it has spread and become the primary disease in various shallot production centers, with alarming incidence rates, including 50% in Brebes (Supriyadi et al. 2021), 80% in Probolinggo (Sholeh et al. 2023), 33.9% in Bantul (Aisyah et al. 2021), and 38.5% in Tanah Laut Regency, South Kalimantan (Safitri et al. 2019). The impact of this disease infection can reduce harvest yields by 50-100% (Herlina et al. 2021). The primary symptoms of Fusarium basal rot disease in shallots are pale green to yellowing leaves that twist, gradually dry out, and softening leading to rot in the bulbs. The pathogen causing Fusarium basal rot disease infects shallot plants at all growth stages, causing symptoms to appear during each development phase (Hanif et al. 2024; Wesoly et al. 2024).

The agronomical practices of Shallot such as planting patterns, variety selection, seed or bulb treatment before planting, crop rotation, and mulch use are related to the development of fusarium basal rot disease in the field. Shallot planting patterns using a polyculture system can suppress the spread of the pathogens causing Fusarium basal rot disease (Sampaio et al. 2021). The infection of fusarium basal rot disease in shallots can also be controlled by using mulch in shallot cultivation. Additionally, shallot cultivation techniques involving crop rotation have been reported to reduce Fusarium basal rot disease development in the field by improving soil fertility and suppressing the source of pathogen inoculum in the form of Fusarium chlamydospores (Ismail et al. 2020; Grilli et al. 2021). This study aims to determine the status of fusarium basal rot disease incidence in Samosir and Karo Regencies, North Sumatera, as well as the relationship between Fusarium basal rot disease incidence and Agronomical practices of shallot by farmers in those areas.

2. METHOD

This study was conducted from March 2022 to January 2023 in Karo Regency at Payung Village and Pangembaten Village, as well as in Samosir Regency at Cinta Dame Village and Sait Nihuta Village.

2.1 Research Design

The research was designed as a descriptive survey to identify the incidence of Fusarium basal rot disease in shallots through field observations and pathogen isolation. The study locations were Payung and Pangembaten villages in Karo Regency (elevation ≈1,200-1,500 m asl, latitude 2°55'-3°05'N, longitude 98°15'-98°25'E), as well as Cinta Dame and Sait Nihuta villages in Samosir Regency (elevation ≈900-1,200 m asl, latitude 2°30'-2°40'N, longitude 98°50'-99°00'E). Data on Agronomical practices of shallot were obtained through survey interviews with 64 shallot farmers, using questionnaires. The criteria for farmers selected as respondents were farmers who had shallot fields with minimum area of 5,000 m².

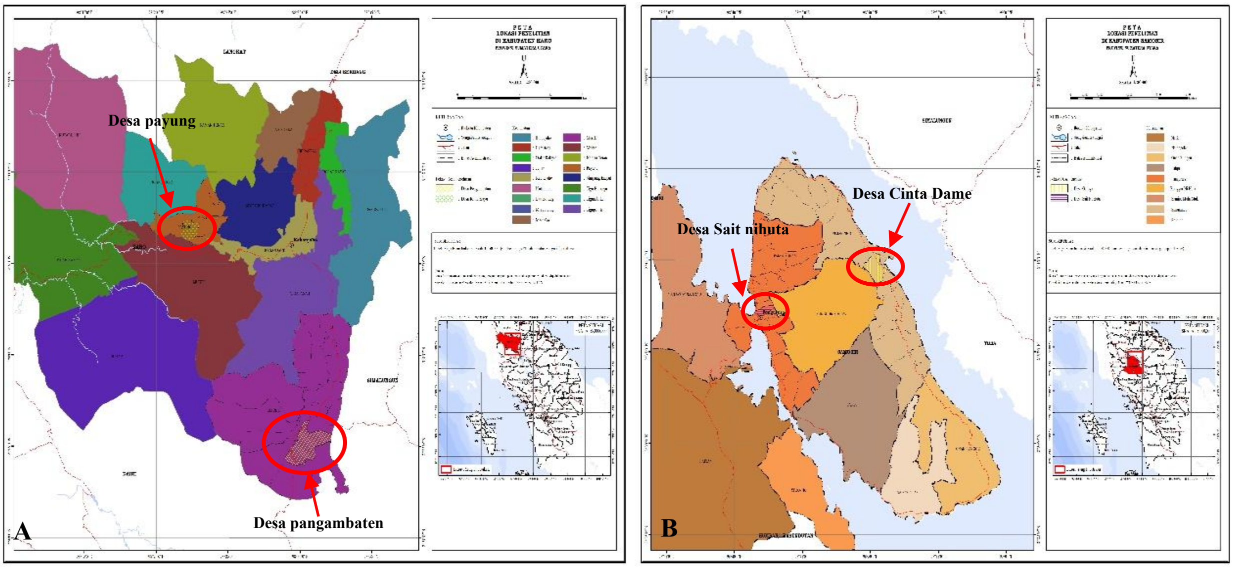

Figure 1. Map of research locations. (A) Karo Regency; (B) Samosir Regency, North Sumatra Province

2.2 Preparation
Preparation involved sterilizing sampling tools (scissors and ziplock bags) by autoclaving at 121°C for 15 minutes and readying standard observation forms. In the laboratory, petri dishes and Potato Dextrose Agar (PDA) media were autoclaved and prepared for pathogen isolation.

2.3 Sample Collection
Sample collection was conducted purposively from 64 shallot fields (minimum 5,000 m², plant age 2-4 weeks) exhibiting Fusarium basal rot symptoms. From each field, 10-30 diseased plants were collected diagonally (5 sampling points, 10% of the population), documented, and stored in a 4°C cooler box for laboratory transport within 24 hours.

2.4 Interview
Semi-structured interviews were conducted in person with 64 farmers (one per field; criteria: >5 years of experience, land area >5,000 m²) using a questionnaire with 30 closed- and open-ended questions. The data covered shallot cultivation practices employed by the farmers, including seed varieties, seed sources, planting patterns, crop rotation, mulch use, application of chemical and organic fertilizers, and pest and disease control for shallots.

2.5 Observation Variables

2.5.1 Signs and symptoms fusarium basal rot disease
The signs and symptoms of fusarium basal rot disease observed in shallot farmers' fields involved shallot plants aged 2 to 4 weeks after planting. Signs of the disease included white hyphae on symptomatic plants. The observed symptoms of Fusarium basal rot disease included leaf color changes from pale green to yellowing, leaf twisting, softening leading to rot at the bulb base, and wilting. Shallot plants showing Fusarium basal rot disease symptoms were counted and documented. The pathogens from shallot plants with Fusarium basal rot symptoms were then isolated in the laboratory by surface sterilizing the plants with 1% NaOCl, rinsing with sterile distilled water, cutting the symptomatic parts into small pieces, placing them on sterile Potato Dextrose Agar (PDA) media, and incubating for 7 days. The fungi that emerged were then observed and identified using the Barnett and Hunter (1998) identification book. (Hanif et al. 2023).

2.5.2 Disease Incidence
Sampling of fusarium basal rot disease incidence was conducted using purposive sampling. Shallot plants showing Fusarium basal rot disease symptoms were counted. Observations were carried out by drawing a diagonal line across the entire shallot population and dividing it into five sample points. The number of shallot plants observed was 10% of the total population (Gomez & Gomez 1984).

The incidence of fusarium basal rot disease was calculated using the formula:

$$Disease\ incidence = \left(\frac{\text{number of symptomatic plants}}{\text{number of plants observed}}\right) \times 100\% \quad (1)$$

2.5.3 Agronomical practices of Shallot Study

Data on Agronomical practices of shallot were obtained through survey interviews with 64 shallot farmers, using questionnaires. The criteria for farmers selected as respondents were farmers who had shallot fields with minimum area of 5,000 m². The collected data included farmer characteristics and Agronomical practices of shallot cultivation by the respondent farmers, covering seed types and varieties, seed sources, planting patterns, crop rotation, mulch use, fertilizer application, and pest and disease control. Subsequently, the data on fusarium basal rot disease incidence and Agronomical practices of shallot were analyzed for their relationship using chi-square tabulation analysis at a 5% significance level and processed with SPSS 16.0.

2.6 Data Analysis

The relationship between shallot agronomical practices and the incidence of basal rot disease in shallots in North Sumatra was analyzed using chi-square tabulation. Disease incidence was grouped into two categories: basal rot incidence ≤ 5% and ≥ 5%. The analysis employed chi-square tabulation at a 5% significance level, with data processed using SPSS 16.0.

3. RESULTS AND DISCUSSION

3.1 Signs and Symptoms of Fusarium basal rot Disease

Disease signs refer to the physical presence of the causal pathogen that can be directly observed on the affected plant tissues. In the case of Fusarium basal rot disease symptoms, the visible signs include white hyphae or chlamydospores on the symptomatic parts of the plant. Plants showing Fusarium basal rot disease symptoms that have been cultured and incubated develop fungal colonies with cotton-like hyphae, ranging in color from white to pale purple. Under microscopic observation, the emerging fungi exhibit crescent-shaped conidia with septa and septate hyphae.

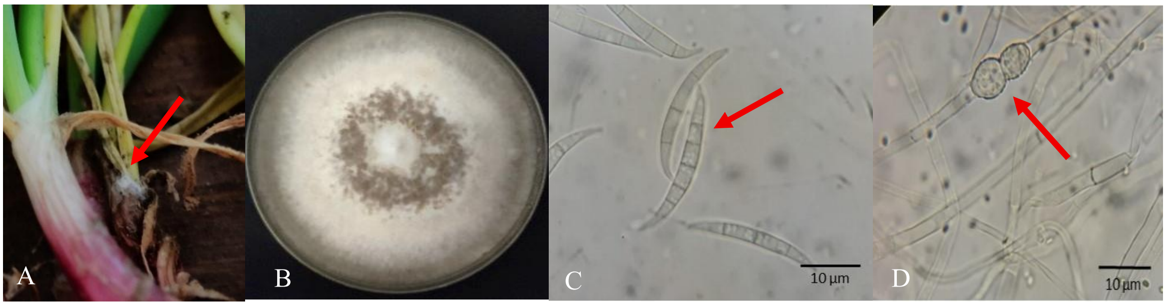

Figure 2. Signs of basal rot disease in shallots. (A) Mycelium on the rotting bulb; (B) Fusarium spp. culture on PDA media; (C) Fusarium spp. macroconidia; (D) Fusarium spp. chlamydospores.

Based on observations of the fungal characteristics obtained from symptomatic shallot plants, it was determined that the fungal isolate is *Fusarium* spp. (Lestiyani et al. 2016; Leslie and Summerell 2006). According to the research by Marianah et al. (2024), fungi isolated from shallot plants showing fusarium basal rot disease symptoms were morphologically and molecularly identified as *F. oxysporum*, *F. solani*, and *F. proliferatum*.

Figure 3. Symptoms of Fusarium basal rot disease (A) Leaf twisting symptom of Fusarium basal rot disease; (B) Fusarium basal rot disease symptom of plant death and drying.

Fusarium basal rot disease in shallot plants is caused by infection with the pathogen *F. oxysporum*, which leads to field symptoms such as leaf twisting, leaf color changing from pale green to yellow, softening and rotting of the bulb base and bulb, and eventually wilting of the shallot plants (Lestiyani et al. 2021).

3.2 Fusarium basal rot disease incidence in shallots in Karo and Samosir

Fusarium basal rot disease incidence in shallots in Karo and Samosir Regencies, North Sumatra, tends to be low, with an average disease incidence of 4.5% at 2 weeks after planting and increasing to 5.5% at 4 week after planting. According to Hanif et al. (2024), Fusarium basal rot disease incidence rises after 2 week after planting. Fusarium spp. infect shallot plants causing symptoms to appear from the early germination phase, with an incubation period of about 2 weeks. Symptoms of *Fusarium* spp. infection typically become visible between 2 and 4 week after planting and increase further if environmental conditions favor *Fusarium* spp. infection (Irfandri et al. 2025). The incubation period for *Fusarium oxysporum* in shallots ranges roughly from 7 to 17 days according to various studies, during which initial symptoms of Fusarium basal rot disease emerge.

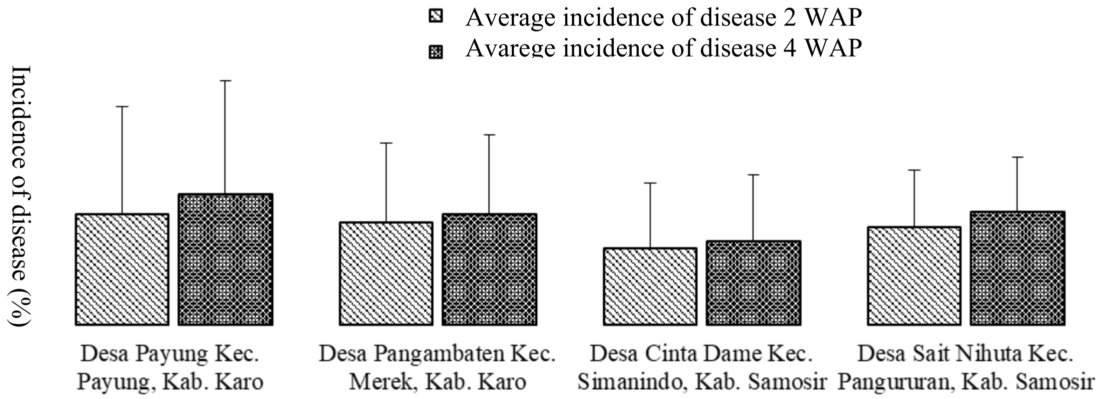

Figure 4. Incidence of Fusarium basal rot disease of shallot in Karo and Samosir Regencies, North Sumatra Province

Infection of fusarium basal rot disease in shallots increases and develops at high temperatures because the growth rate of Fusarium spp. rises in warm conditions (Gordon et al. 2019). Chakrapani et al. (2023) reported recent findings indicating that warm environmental conditions accelerate the development of Fusarium spp. on shallot plants, thus increasing the severity of wilt disease and confirming a strong relationship between temperature and the intensity of *Fusarium* spp. infection. Additionally, soil pH influences Fusarium basal rot disease development. Alkaline soil conditions reduce *Fusarium* spp. conidia germination by 73.1%, so lower soil pH tends to increase the incidence and severity of Fusarium basal rot disease in shallots in the field (Panwar et al. 2016). The study locations are in highland areas: Karo Regency at 400-1600 meters above sea level (masl) with temperatures of 15-23°C and 89% humidity, and Samosir Regency at 900-1500 masl with temperatures of 7-27°C and 85% humidity. Temperature conditions in both regencies tend to be low. Furthermore, Marbun et al. (2021) reported that the soil pH level of 5.44 in Karo Regency classifies the soil as acidic, which correlates with the generally low occurrence of shallot Fusarium basal rot disease in Karo and Samosir Regencies.

3.3 The Relationship Between Agronomical practices of Shallot and the Incidence of Fusarium basal rot Disease in Shallots

Agronomical practices of shallot that correlate significantly with the incidence level of fusarium basal rot disease in shallots are shallot varieties, planting patterns, the use of organic fertilizer, and also the use of plastic mulch.

Table 1. The relationship between agronomical practices and the incidence of Fusarium basal rot disease in shallots

Agronomical practices		Incidence of disease		X^2	P*
		≤ 5%	≥ 5%		
Varieties	Batu Ijo	15	4	11,672	0,04*
	Maja	6	4		
	Sakato	4	5		
	Bima	5	2		
	Bauji	12	0		

	Biru Lancor	3	4		
Bulb source	Farm shop	25	11	4,748	0,191
	Other Farmers	12	5		
	Making own seedlings	2	3		
	Goverment aid	6	0		
Cropping pattern	Monoculture	13	11	4,796	0,029*
	Polyculture	32	8		
Intercrop plants	No intercropping	13	11	8,841	0,356
	Corn	8	1		
	Red pepper	12	4		
	Tomato	2	1		
	Orange	5	0		
	Dragon fruit	1	0		
	Tobacco	2	0		
	Potato	1	1		
	Peanuts	1	1		
Crop rotation	Yes	36	11	3,346	0,067
	No	9	8		
Use of plastic mulch	Yes	32	7	7,59	0,006*
	No	12	12		
Use of organic fertilizer	Yes	25	4	6,41	0,011*
	No	20	15		
Use of chemical fertilizers	Yes	40	14	2,24	0,126
	No	5	5		

*The P-value < 0.05 indicates there is an association between cultivation factors and the severity of basal stem rot disease with n = 64.

There is a relationship between the incidence of disease and the environment, plant variety, and pathogen virulence related to the disease triangle concept. These three factors are interconnected, leading to the development of plant diseases in the field. The host plant variety is closely related to disease development. Shallot varieties used in the observation locations of the study were Sakato, Bima, Batu Ijo, Maja, Bauji, and Biru Lancor. Based on research by Aprilia et al. (2020) and Prakoso et al. (2016), Batu Ijo is a resistant variety, while Bauji, Maja, and Bima are susceptible varieties to Fusarium basal rot of shallot disease. Additionally, shallot cultivation with a polyculture pattern also influences the reduction of Fusarium basal rot of shallot disease incidence in the field. These results align with the study by Chang et al. (2020), which reported that the intercropping between soybean and maize can reduce Fusarium root rot by 37% compared to the monoculture system. Intercropping among the main shallot plants affects environmental conditions such as temperature, microenvironment humidity, vector spread, rainfall, and wind direction, thus polyculture in shallot farming can suppress the development of Fusarium basal rot disease (Aisyah et al. 2021).

The use of plastic mulch in shallot cultivation at the research site also showed a significant correlation of 0.006 with the reduction in Fusarium basal rot incidence. The application of plastic mulch significantly reduced root rot and wilt incidence by 80-90% in cucumber plants (El-Hadidy 2013). Plastic mulch in shallot cultivation is also significantly correlated with reducing the incidence of Fusarium basal rot disease. Plastic mulch in shallot cultivation can reduce weeds, prevent excessive evaporation, increase soil micro-temperature, promote beneficial soil microbial growth, and prevent pest vectors, thereby preventing the development of soil-borne plant diseases (Iqbal et al. 2020; Steinmetz et al. 2016; Ngosong et al. 2019). The presence of antagonistic microorganisms in organic fertilizers can suppress pathogens causing fusarium basal rot disease, and the organic compounds produced can induce the defense system in the host plant (Bonanomi et al. 2018). Reported organic fertilizers that reduce fusarium basal rot disease incidence include those with added fungi *Trichoderma harzianum*, rabbit urine manure, composted straw, chicken manure, and mushroom waste, which have been reported to suppress fusarium basal rot disease incidence by up to 60% (Gofar et al. 2023; Wahyuni et al. 2023; Lasmini et al. 2022).

The results of this study recommend that shallot cultivation using resistant varieties such as Batu Ijo, plastic mulch application, intercropping techniques of cultivation, and organic fertilizer use, can serve as appropriate recommendations to prevent Fusarium basal rot disease in shallot cultivation.

4. CONCLUSION

The incidence of fusarium basal rot disease in Karo and Samosir Regencies, North Sumatera Province, is generally low. This condition is due to the environmental temperatures in the research area, which are not conducive to the growth of the disease. Important shallot cultivation factors contributing to the low fusarium basal rot disease incidence in these regions include the chosen shallot varieties, the polyculture planting system, the use of plastic mulch, and the application of organic fertilizers. Therefore, it is recommended to use resistant varieties such as Batu Ijo, shallot cultivation with intercropping cultivation, plastic mulch application, and organic fertilizers use to prevent of fusarium basal rot disease in shallot cultivation. Further studies incorporating molecular pathogen identification and quantitative environmental measurements are recommended to strengthen causal interpretation.

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