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CHAPTER I

INTRODUCTION

A. Background.

Shallot (*Allium ascalonicum* L.) is one of the leading vegetable commodities that has an important meaning for the community both in terms of high economic value and nutritional content (Permana *et al.*, 2021). According to Haryati *et al.* (2024) and Budiarti *et al.* (2022) shallots are one of the strategic commodities in Indonesia, because the price increase can be one of the causes of high inflation. Shallots are also one of the multipurpose shallot vegetables with high economic value (high value commodity) so that the demand for shallots is *high* and the majority of farmers cultivate them. In addition, there are other benefits for health such as biochemical content such as antioxidants that can lower cholesterol and sugar levels.

The development of shallot planting in Indonesia technology uses True Shallot Seed (TSS). True Shallot Seed refers to botanical seed (seed from flowering and seed-set) of shallots (typically *Allium cepa* var. *aggregatum* or *Allium ascalonicum*) rather than the more common vegetative propagation via bulb sets or tubers. TSS technology as an alternative way to increase shallot yield and cultivation efficiency (Hakim *et al.*, 2022). The development of shallot cultivation in Indonesia using TSS in the Sanren, Merdeka, and Maserati varieties shows promising progress in increasing productivity and crop quality. Sanren and Merdeka varieties that have been registered as TSS superior seeds have good adaptation and are able to increase production yields to 18 tons per

hectare (Cahyani. 2022), while the Maserati variety has also been introduced as part of the diversification of TSS superior varieties (Sayaka *et al.*, 2020).

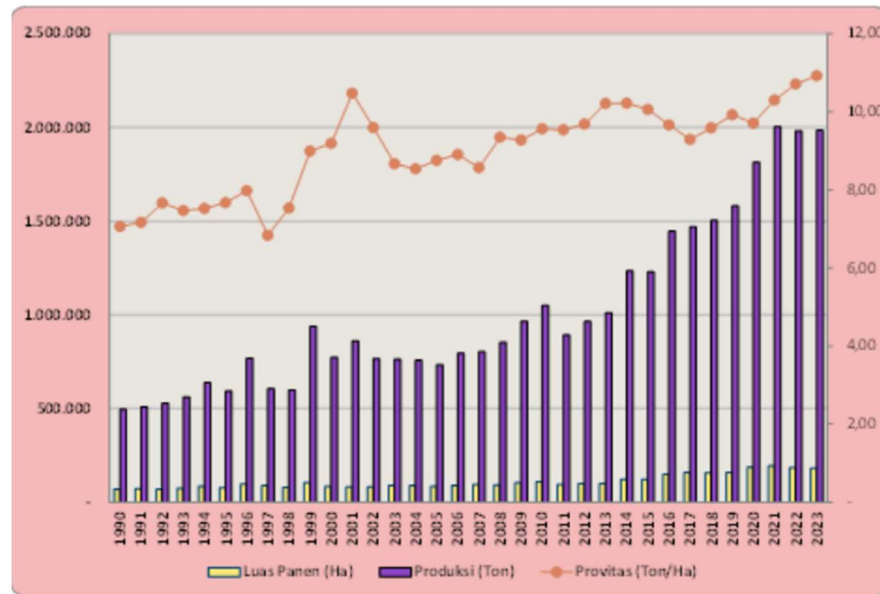


Figure 1.1 The Development of Harvested Area, Production, and Productivity of shallot in Indonesia, Years 1990-2023
(Source: Badan Pusat Statistik Indonesia, 2024)

Fluctuations in the expansion of shallot harvested area occurred over both the three-decade period (1990–2023) and the past five years (2019–2023), with annual growth rates of 3.52% and 3.27%, respectively. During the last ten years (2014–2023), significant increases of over 10% are recorded in 2014, 2016, and 2020, with growth rates of 22%, 22.53%, and 17.40%. In 2023, however, the harvested area declined by 1.78%, equivalent to about 3.3 thousand hectares. (Figure 1.1) (Badan Pusat Statistik Indonesia, 2024). One of the challenges faced in shallot cultivation is the decline in productivity caused by infections from various types of pathogens that can attack the plants. (Cahyani. 2022). Plant pathogen attacks such as disease infections caused by fungi, bacteria and viruses are one of the obstacles faced in shallot cultivation

and can reduce production yields. Some diseases commonly found in shallot plants include: a) fusarium wilt (*Fusarium oxysporum*), b) stemphylium leaf blight (*Stemphylium vesicarium*), c) Purple blotch (*Alternaria porri*), and d) anthracnose (*Colletotrichum gloeosporioides*).

Plant disease suppression is one of the important strategies in sustainable agricultural cultivation, and this effort can be enhanced through the utilization of natural materials such as coconut water, Plant Growth Promoting Rhizobacteria (PGPR), and silica. Coconut water contains natural growth hormones such as cytokinin, auxin, and gibberellin that can stimulate plant growth and strengthen its natural immune system (Jannah, 2023). PGPR, microorganisms that live around plant roots, can produce antimicrobial compounds and induce systemic resistance, making plants more resistant to various diseases. Meanwhile, Silica plant nutrients are known to strengthen plant cell walls, thereby increasing physical resistance to pathogen attack (Sholihah and Hamawi, 2024). The combination of these treatment will be great potential in reducing the intensity of disease attacks in an environmentally friendly manner without leaving harmful chemical residues.

This study compares the use of three fertilizer and the various varieties to be used and aims to understand the relationship between these agronomic factors for disease incidence and disease intensity on the farm. Through this approach, researchers can identify good plant nutrients for crops as well as varieties that are resistant to diseases. This study is important for designing more effective and environmentally friendly disease control strategies, taking

into account the interaction between plant nutrients and varieties, disease severity per day, and crop production. The results of this study can be used as a basis for decision-making in the selection of superior varieties and appropriate fertilization to support sustainable agriculture (Jannah, 2023).

B. Problem formulation

1. Which interaction between fertilizer treatments and TSS shallot varieties is most effective in reducing the level of disease infection in shallot plants?
2. Which fertilizer treatment is most effective in reducing the level of disease infection in shallot plants?
3. Which TSS shallot variety has the highest level of diseases resistance in shallot plants?

C. Research Objectives

1. To determine the effect of the interaction between fertilizer treatments and TSS shallot varieties in reducing the level of disease infection in shallot plants.
2. To determine the fertilizer treatment that is most effective in reducing the level of disease infection in shallot plants.
3. To identify the TSS shallot variety with the highest level of resistance to disease in shallot plants.

D. Uses of Research

This study is expected to provide scientific information and broaden knowledge regarding the effectiveness of various fertilizer treatments, the level of resistance of several True Shallot Seed (TSS) varieties, as well as the interaction between both factors in suppressing disease attacks in shallot plants. The results of this study can serve as a reference for future research related to disease management and the improvement of shallot productivity.

CHAPTER II

LITERATURE REVIEW

A. Shallot

Shallot (*Allium ascalonicum* L.) is a plant from the Middle East and was known in Indonesia in the 8th century. Shallot plants are included in superior horticultural crops that have been cultivated by farmers intensively and are a source of income for farmers so that they can make a high contribution to economic development in several regions (Kurniasih *et al.*, 2023). The systematics of shallot plants are classified as follows:

Kingdom : Plantae

Division : Spermatophyta

Class : Monocotyledonae

Order : Liliales

Family : Liliaceae

Genus : Allium

Species : *Allium ascalonicum* L. (Herlina, 2023).

Shallot morphology consists of roots, stems, leaves, flowers, and seeds. Shallot plants have fibrous roots with a shallow root system and scattered root branches. Shallot roots can penetrate the soil to a depth of 15-20 cm in the soil. The number of roots of shallot plants can reach 20-200 roots. Root diameter varies, ranging from 2 to 5 mm. root branching can reach 3-5 branch roots (Herlina, 2023).

Shallot stems are divided into 2 types, namely true stems and pseudo stems. The true stem of shallots or called *discus* is disk-like, thin, and short. The function of the *discus* in shallots as a place to attach roots and bud eyes (Putri, 2024). The pseudo stem is above the *discus* which is composed of fronds of leaves and stems of all different shapes in the soil. A group of fronds will be arranged into a shallot layer (*shallotus*). Between the layers of shallotus petals there are bud eyes that can form new plants (Herlina, 2023).

Morphologically, leaves generally have parts of the leaf blade (*lamina*), and *petiole* (*petiolus*). The leaf blade of shallot is green and small cylindrical with a pointed tip. The length of the leaves can extend between 50-70 cm (Putri, 2024) and many leaflets reach 22-43 leaflets (Harahap *et al.*, 2022). Although shallot leaves are cylindrical, but the inside is hollow with holes like a pipe shape, sometimes there is also a semicircular leaf shape (Herlina, 2023). The location of the leaves is attached to the stalk which is relatively short in size. The outer leaf petals are circular and close the leaves inside (Putri, 2024).

Shallot flowers come out from the tip of the plant (growing point) which is between 30-90 cm long, and at the end there are 50-200 flowers arranged in a circle as if in the form of an umbrella. Each flower consists of 5-6 white flower leaves, 6 green or yellowish stamens, 1 pistil and an almost triangular fruit. Red-colored shallot seeds are used to propagate the plant, seed acquisition is done on the flower. Shallots are capable of flowering at the age of 52 days. Age until harvest is 70 days (Putri, 2024).

Shallots can grow in varied places. Shallots can grow and produce well in the lowlands to highlands around 900 m above sea level. Shallots can grow in the lowlands with a favorable climate and sufficient sunlight. Shallot irradiation is classified as maximum (about 70% irradiation) (Herlina, 2023) with a good environmental temperature of 25-32 °C (Putri, 2023). The desired rainfall is around 300-2500 mm/year with relative humidity of 50-70%. Shallot plants are not resistant to drought because they have short roots (Putri, 2023).

Shallots can be planted in rice fields after the rice harvest and in the soil in moorland areas, gardens, and yards. The type of soil required for shallot planting is sandy loam or dusty loam. In addition, loose and fertile soil can encourage the development of the shallots (Harahap *et al.*, 2022). Suitable soil acidity for shallot plants is pH 5.5-6.0. If the planting soil is too acidic, it can cause stunted plant growth. This is due to the high content of aluminum (Al) salts which are toxins in plants. While the soil that is too alkaline can inhibit shallot growth, the cause of small shallot size is due to the content of manganese (Mn) which cannot be absorbed by plants quickly (Souminar, 2017).

B. True Shallot Seed

The development of True Shallot Seed (TSS) overcomes the problem of using shallots as seeds that are used in the long term. The use of shallots as seeds has several disadvantages where it does not have a long shelf life, especially when the rainy season arrives so that the supply of shallots becomes limited. The advantages of using TSS as seeds include increasing the yield of shallots

twice as much as seeds derived from shallots, harvesting shallots has a good shelf life of shallots up to a shelf life of 1-2 years, has good harvest quality, and is more protected from plant diseases and viruses (Harahap *et al.*, 2022). Some types of TSS seeds used for cultivation in Indonesia are the Sanren, Merdeka, and Maserati varieties:

1. Sanren Variety

Sanren shallot is one of the superior shallot varieties developed through hybrid seed technology in a cross between BM 2408 and BM 4811. This variety was developed by PT East West Seed Indonesia (EWINDO), a national horticultural seed producer that has conducted research and testing for ten years before finally introducing Sanren F1 widely in Indonesia. This variety is characterized by a plant height of about 54.03- 56.50 cm, flat round leaves with a length of 40.50-46.95 cm and a width of 0.54-0.85 cm, and dark green leaves. Each shallot has 8-10 leaves, while the number of leaves per clump is 29-36 (Direktoral Jendral Hortikultura, 2013).

Storability of sanren variety shallots up to 122-128 days after harvest with room temperature during the day 29-31 °C and night 25-27 °C. Weight loss occurs of shallot yield up to 36.7%-39.5%. Seed requirement per hectare is 1.9-20 kg with a planting population per hectare of about 460,000 – 406,607 plants. The harvest productivity of this variety is relatively high where yields reach 23.23-28.14 tons per hectare more heavy than the another TSS varieties (Direktoral Jendral Hortikultura, 2013). The advantage of the Sanren F1 variety is the variety designed to produce good

shallots in all existing tropical seasons, less of the water ground, and good shallot yields that are in demand by the national market. Sanren F1 variety grows optimally in lowland areas at an altitude of 50-100 m above sea level (masl). (Surur *et al.*, 2022).

2. Merdeka Variety

Merdeka F1 variety, also known as BM 9008, is a hybrid seed produced by PT East West Seed Indonesia from the crossing of BM 9242 and BM 266. The variety was issued in the Minister of Agriculture Decree No. 072/Kpts/SR.120/D.2.7/7/2013. The BM 9008 variety has a plant height of 56.15-61.08 cm with a triangular leaf cross-section shape. The leaf size is 43.43-49.79 cm long and 1.37-1.45 cm wide with green leaves. Leaf density is relatively dense with a weak waxy coating. At harvest age, the number of leaves per clump reaches 8-12 leaves and the number of leaves per clump is 30-45 leaves (Direktoral Jendral Hortikultura, 2023).

Shallot harvesting age is 64-77 days after planting and production per clump can produce 5-8 shallots with a weight per shallot weighing 9.51-12.25 grams. The storability of shallots at room temperature (25-30°C) can reach 123-131 days after harvest with shallot weight loss reaching 27.09-34.34%. Population per hectare reached 533,333 plants with seed requirement per hectare 2.49-4.04 kg. Shallot yield per hectare reaches 18.89-26.77 tons (Direktoral Jendral Hortikultura, 2023).

The main characteristics of the BM 9008 variety are the basic color of the purple red shallot skin with a longitudinal cross section of the rhombic

shallot and the shape of the tip of the shallot is very oblique. The advantage of the BM 9008 variety is the large number of tillers produced and the size of the shallot is quite large, it is noted that the fruit production per unit area is high (18.89-26.77ton ha⁻¹). The variety can grow in lowland and upland areas during the rainy season. In addition, this variety is highly resistant to fusarium wilt and anthracnose disease (Direktoral Jendral Hortikultura, 2023).

3. Maserati variety

Maserati variety is produced by PT Agrosid Manunggal Santosa. This variety comes from a Dutch introduction through Bejo Zaden B.V. is the result of a cross between BR A4 (2) with X IND B FX (3). Maserati is classified as a hybrid shallot. Maserati plant height ranges from 46.31 to 54.03 cm. The leaves have a triangular cross-section, measuring between 34.72-52.13 cm long and 0.63-1.04 cm wide. Leaf color is green (RHS N 137 C). Each shallot has about 8-11 leaves, while the number of leaves per clump ranges from 22-32 (Direktoral Jendral Hortikultura, 2018).

The yield of shallots per hectare is high, reaching 24.41-27.90 tons, with a planting population of 250,000 plants per hectare, and seed requirements of 0.9900-0.9978 kg per hectare. The storability of shallots at room temperature is 101-125 days after harvest with weight loss reaching 14.34-33.70%. The main characteristics of this variety are triangular leaf cross-section, green leaf color (RHS N 137 C), purple shallot color (RHS N 798), and rombic shallot shape with characteristic prominent base, flat tip,

and narrow neck. The advantages of the Maserati variety include high productivity per hectare, early harvest age, and a large number of shallots and tillers per clump. This variety is suitable for planting in the middle plains during the dry season (Direktoral Jendral Hortikultura, 2018).

C. Coconut water

Coconut water plant nutrient is a liquid organic plant nutrient made from coconut water, both young and old coconut water, which is fermented and used to fertilize plants. From an industrial point of view, coconut water is often considered as an unusable waste due to the utilization of coconut fruit as the main raw material. Coconut water plant nutrients can be used as an alternative to chemical plant nutrients, and are easily applied either by watering to the roots or spraying to the leaves of plants. The fermentation process in making coconut water plant nutrients produces simpler compounds and is easily absorbed by plants, while increasing the activity of beneficial soil microorganisms (Darmawan *et al.*, 2022).

The nutritional content of coconut water plants is diverse, including macro and micro nutrients such as potassium (K), nitrogen (N), calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe), copper (Cu), sulfur (S), as well as carbohydrates, sugars, proteins, and amino acids that can trigger the growth of plant roots and stems (Al Banna and Ilmiyah, 2023). In addition, micro and macro content can also strengthen plant resistance to pathogen attacks. Suppression is done by increasing plant metabolism and regenerating dead cell tissues (Batubara *et al.*, 2021).

In addition, coconut water also contains natural growth hormones such as auxins and cytokinins that play an important role in the process of cell division and the growth of new shoots in plants. The content contained in coconut water can spur plant cell growth by 20-70% (Al Banna and Ilmiyah, 2023). The mineral content in coconut water can strengthen the plant's immune system and reduce plant stress which can suppress disease development (Batubara *et al.*, 2021).

D. PGPR

Plant Growth Promoting Rhizobacteria (PGPR) is a group of beneficial bacteria that live in the area around plant roots (rhizosphere) and have an important role in supporting plant growth and health. These bacteria form colonies around the root system and influence plant physiological processes in various ways, such as producing growth hormones (such as auxins, cytokinins and gibberellins), providing nutrients and helping to suppress pathogens. PGPR is also a natural solution to reduce dependence on chemical plant nutrients and pesticides, thus contributing to more sustainable and environmentally friendly agricultural practices (Jha and Saraf, 2015).

The main content of PGPR plant nutrients are bacterial microorganisms that have multifunctional abilities, namely as biofertilizers, biostimulants, and bioprotectants. As a biofertilizer, PGPR is able to bind nitrogen from the air asymbiotically and dissolve phosphate bound in the soil so that nutrients are more available to plants. As a biostimulant, PGPR produces growth hormones

such as auxins, cytokinins, and gibberellins that stimulate root and shoot development. Meanwhile, as a bioprotectant, PGPR produces antibiotic compounds, lytic enzymes (chitinase, glucanase), and siderophores that inhibit the growth of plant pathogens around the roots (Asra *et al.*, 2024).

The benefits of PGPR plant nutrients in plant disease suppression are significant due to their ability to control pathogens directly or indirectly. PGPR produces antimicrobial metabolites that can kill or inhibit the growth of disease-causing fungi and bacteria, and compete with pathogens for nutrients in the rhizosphere. In addition, PGPR also induces the plant defense system by stimulating the production of natural defense compounds, so that plants become more resistant to pests and diseases (Asra *et al.*, 2024).

E. Silica

Silica plant nutrients are plant nutrients that contain the element silica (SiO_2) which plays an important role in improving soil quality and plant growth. Silica is the second most abundant element after oxygen in the earth's crust and is an important element after nitrogen (N), phosphorus (P), and potassium (K) in cereal crops. Silica plant nutrients can come from inorganic materials such as mineral rocks and organic materials such as rice husks and straw which contain high amounts of silica (Yuniarti *et al.*, 2017).

Silica plant nutrients contain the main compound in the form of silica (SiO_2), which plays a role in improving the physical structure of the soil by helping to retain moisture and increase the soil's ability to store water. Silica

also contributes to the stability of root cell membranes, strengthens the structure of plant cell walls, and supports the activity of enzymes that play a role in the photosynthesis process. The benefits of coconut silica in plant disease suppression are based on its ability to strengthen plant cell walls so that plants become more resistant to pests and pathogens. The increased cell wall thickness serves as a physical barrier against the penetration of disease-causing microorganisms. (Yuniarti *et al.*, 2021).

Silica's other plant nutrient content also helps increase the availability of essential nutrients such as nitrogen, phosphorus, and potassium, which have a positive impact on plant growth. Recent innovations using silica in nano form have proven to be more effective in increasing nutrient absorption and strengthening plant resistance to various environmental stresses. In addition, other benefits include increasing root oxidation and photosynthetic enzyme activity that helps plants maintain health and natural resistance to various plant diseases (Yuniarti *et al.*, 2021).

F. Shallot diseases

1. Fusarium wilt (*Fusarium oxysporum*)

Fusarium wilt, often referred to as disease, is one of the main problems in shallot cultivation caused by infection with the fungus *Fusarium oxysporum* f.sp. *cepae* (Hanz.) Snyder & Hans. This fungus is able to cause 10-15% of seedlings to be unable to grow completely, resulting in chlorosis of the shoots that grow and fall to the ground and then rot