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Effect of Soil Texture on the Productivity of Two Shallot Varieties

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Abstract. The Lake Toba Catchment Area (LTCA) has long been known as a producer of shallots in North Sumatra. The Samosir variety is the mainstay local variety of the farmers. Due to the lack of quality seeds and disease attacks on the Samosir variety, farmers began to cultivate the Bima Brebes variety. This study aims to prove the difference in productivity of shallot varieties Samosir and Bima Brebes cultivated in the LTCA region by considering soil texture as a factor affecting productivity. This study was conducted in 6 shallot producing districts included in the LTCA. For analysis, 30 samples were selected based on the level of shallot productivity, with details of 10 low category production (< 4.5 tons/ha), 10 medium category production (4.5-7.5 tons/ha), and 10 high category production (> 7.5 tons/ha), along with the results of soil texture analysis. Correlation analysis was conducted to find the type of soil fraction that influenced productivity. ANCOVA to analyze the relationship between soil fraction and shallot productivity in each variety and analyze the difference in the productivity of Samosir and Bima Brebes shallots. The results showed that the sand fraction had an effect on shallot productivity in LTCA. The shallot cultivation land in LTCA has a sand fraction of 69-76% (sandy loam texture), where the greater the percentage of sand fraction, the higher the productivity of both shallot varieties. There was no difference in the productivity of Samosir and Bima Brebes shallots varieties. Bima Brebes variety can be a substitute seed for shallot cultivation in LTCA.

Keywords: Lake Toba catchment area, productivity, sand fraction, shallot, variety

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1. Introduction

Shallots (Allium cepa L.) have been cultivated as a vegetable or seasoning since ancient times. In addition, shallots have long been known as a medicinal plant [1]. Shallot is one of the most important crops cultivated in millions of hectares worldwide [2]. FAO data show that 3.7 million hectares are planted with onions yearly in about 175 countries [3].

Shallots are widely grown in Indonesia and are high-value crops. This species includes many varieties developed by the government and the private sector because of their distinctive characteristics, such as yield, resistance to disease, taste, smell, and color [4]. For Indonesia, the

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shallot is a commodity of high economic value and has a vast market prospect. In addition to meeting domestic needs, it is also targeted to become one of the export commodities [5].

Sumatra Utara Provincial Government pays special attention to the shallot commodity because it is one of the sources of inflation triggers and in order to achieve shallot self-sufficiency [6]. Lake Toba Catchment Area, a highland area in North Sumatra, has long been known as a shallot-producing center. This area is famous for its local shallots, namely the Samosir (Medan) variety. Shallots of the Samosir variety are location-specific; if planted in other areas, the aroma will differ [7].

Lack of quality local seeds and disease outbreaks in the last decade have caused a sharp decline in shallot production in the Lake Toba Catchment Area. Various efforts were made to meet the needs of shallots in this region, including disease control efforts and new varieties cultivation. Bima Brebes is a shallot variety with high productivity and adaptability [8], characterized by a savory taste and a fragrant sulfur aroma [9]. These critical characteristics attract local farmers to cultivate shallots of the Bima Brebes variety in the Lake Toba Catchment Area.

The spatial variability of soil properties affects the yield of shallots [10]. Soil texture significantly affected the productivity of shallots in LTCA [7] and [11]. Soil texture is a physical property of soil that is difficult to change and takes a long time to change [12]. Soil texture is determined by the percentage of sand, silt, and clay particles, where small particles (silt and clay) have a larger surface area compared to larger sand particles [13]. Soil texture affects many physical and chemical properties of the soil so that it affects soil fertility and productivity [14]. Soil texture affects plant growth and nutrient absorption because it changes the availability of water in the soil [15]. The variations in soil particle sizes changed the soil's physiochemical characteristics and enzymatic activities [13]. An essential indicator of a soil's potential productivity is its texture [16].

This study aims to analyze the effect of soil texture on the productivity of the local and new shallot varieties (Samosir and Brebes varieties) in LTCA. We hypothesize that the soil texture in the study area still supports the growth of shallots of the Bima Brebes variety as an introduced variety so that its production is equivalent to the production of the Samosir variety as the mainstay variety in the location.

2. Materials and Methods

This research was conducted in 6 shallot-producing regencies namely Karo, Simalungun, Dairi, Samosir, Humbang Hasundutan and North Tapanuli that are included in LTCA. It is an area around Lake Toba with delineation boundaries based on the delineation of the Water Catchment Area. Geographically it is located between the coordinates 98°25'40'' – 99°14'35'' East Longitude

and 2°13'07'' - 2°44'26'' North Latitude. Located in Bukit Barisan mountains with an altitude of 900 - 2200 m above sea level.

This study was conducted by recording the shallot production of each farmer through a questionnaire and taking soil samples from the shallot plantation. For analysis, 30 samples were selected based on the level of shallot productivity, with details of 10 low category production (< 4.5 tons/ha), 10 medium category production (4.5-7.5 tons/ha), and 10 high category production (> 7.5 tons/ha). The initial plan of 30 samples consisted of 15 each of Samosir and Bima Brebes varieties. However, from the data obtained, only 13 samples of Bima Brebes variety data were available. Selected samples were analyzed for soil texture (using the hydrometer method).

This research is using 2 analyses:

a. First, Correlation analysis. The purpose of this step is to find the correlation of soil fraction with shallot productivity.
b. Second, Analysis of Covariates (Ancova). Ancova is a combination of comparative and correlational tests, in this case it will test the comparison and also the relationship. In this study, the test was conducted to analyze the difference in productivity of Samosir and Bima Brebes shallots and analyze the relationship between soil fraction and shallot productivity in each variety.

3. Results and Discussion

3.1. Productivity

The statistical productivity (ton/ha) description of Samosir and Bima Brebes varieties of shallots in LTCA can be seen in Table 1.

Table 1. Statistical Productivity (ton/ha) Description of Samosir and Bima Brebes Varieties of Shallots in Lake Toba Catchment Area

Shallot variety	N	Min	Max	Mean	Std. Deviation
Samosir	17	2.00	16.67	7.57^{ns}	4.703
Bima Brebes	13	1.60	12.50	5.65^{ns}	3.316

ns = not significant at $p \leq 0.05$

Table 1 shows no statistical difference in productivity (by T-test) between the Samosir variety (a local variety in the Lake Toba Catchment Area) and the Bima Brebes variety as an introduced variety. Although the Bima Brebes variety is a shallot variety intended for lowland areas [17], it has a high adaptation to highland areas.

3.2. Soil Texture

Soil texture is the relative proportion of sand, silt, and clay particles in the soil and is an important component of soil surveys to estimate the potential and limitations of land use and management

[18]. The description of the sand, silt and clay fractions of all 30 soil samples for analyzing shallot cultivation in LTCA can be seen in Table 2. All analyzed soil samples for texture according to the USDA texture triangle are belong to the sandy loam texture class. The USDA soil texture triangle is a diagram often used to figure out a soil textural class of the soil [19].

Table 2. Statistical Soil Fraction Description of Shallot Cultivation in Lake Toba Catchment Area

Fraction	Samosir Shallot Variety					Bima Brebes Shallot Variety				
	N	Min	Max	Mean	Std. Dev.	N	Min	Max	Mean	Std. Dev.
Sand_%	17	69	75	71.65	2.473	13	70	76	72.15	2.075
Silt_%	17	13	21	17.59	2.623	13	11	20	16.46	2.696
Clay_%	17	10	14	10.82	1.286	13	10	16	11.38	1.758

The soil of shallot cultivation in LTCA has a sandy loam texture (Table 2). Sandy loam texture has advantages over soil texture with a higher percentage of sand fraction (loamy sand and sand texture). [20] proved that, plant N uptake and crop yields on fully irrigated land were higher in sandy loam textures than loamy sand and sand textures. The ability of sandy loam texture soil can still be improved by adding biochar. Giving biochar with sizes < 1mm to sandy loam soils will greatly increases water availability and soil structure [21], reduces bulk density [22], and increases nutrient retention [23].

3.3. Correlation of Soil Fraction with Productivity

Table 3 shows the correlation of sand, silt and clay fractions with the productivity of Samosir and Bima Brebes shallots varieties in Lake Toba Catchment Area.

Table 3. Correlation of Soil Fraction with Shallot Productivity in Lake Toba Catchment Area

Fraction	Productivity	
	Samosir Variety	Bima Brebes Variety
Sand	0.662**	0.580*
Silt	-0.668**	-0.550^{ns}
Clay	0.179^{ns}	0.158^{ns}

** = significant at $p \leq 0.01$; * = significant at $p \leq 0.05$; ns = not significant at $p \leq 0.05$

Table 3 shows the correlation of soil texture fractions with the productivity of shallots in the Lake Toba Catchment Area. The percentage of clay fraction, although positively correlated but not significantly correlated with the productivity of shallots. The percentage of silt fraction shows a negative correlation with productivity. Significantly negative correlation with shallot productivity of Samosir variety but not significantly negative correlation with productivity of Bima Brebes variety. The percentage of sand fraction is significantly positively correlated with increasing the productivity of shallots. Thus, only sand fraction used in the next step, Ancova analysis.

3.4. Effect of Soil Fraction on Productivity Each Variety

Before being analyzed using ANCOVA, the data has been confirmed to meet the normality test (Kolmogorov test), and homogeneity test (Levene's test). ANCOVA test results can be seen in Table 4.

Table 4. Ancova Test Table

	df	F value	Sig.
Corrected Model	2	10.359	.000
Intercept	1	15.398	.001
Sand	1	18.225	.000
Variety	1	4.187	.051

R Squared = .434 (Adjusted R Squared = .392)

From Table 4 can be seen that for varieties, the sig value is 0.051, greater than 0.05. This means that there is no significant difference in productivity between shallot varieties. For Covariate (percentage of sand fraction) sig value is 0.000, less than 0.05. This means that the percentage of sand fraction has a very significant effect on the productivity of shallots. For Corrected Model the value of sig is 0.000, less than 0.05. Simultaneously the percentage of sand fraction and variety has a very significant effect on the productivity of shallots (Figure 1). The value of R squared is 0.434, means that 43.4% of the productivity of shallots in LTCA is influenced by the percentage of soil sand fraction and shallot varieties.

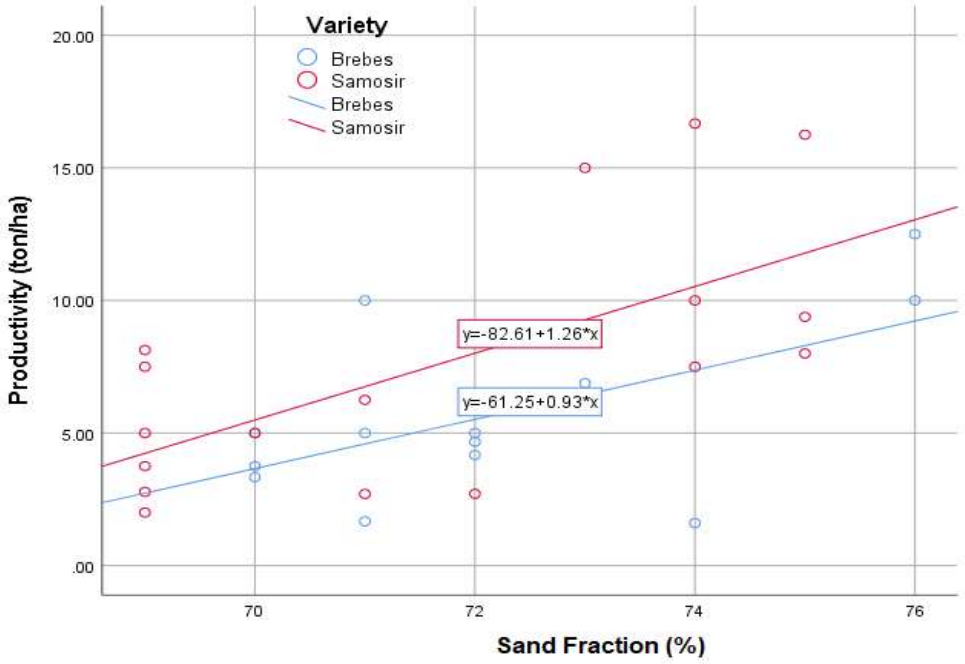

Figure 1. The relation between sand fraction and productivity in each variety

Although Bima Brebes variety productivity is lower than Samosir variety which is a local variety in LTCA (Table 1), statistically the productivity is not significantly different (Table 4). Bima Brebes variety is able to produce as well as the Samosir variety which is a mainstay local variety.

This proves that Bima Brebes variety is able to produce well in the highlands of Lake Toba Catchment Area. Several studies have shown the ability of Bima Brebes variety compared to other shallot varieties. [8], [24] and [25] stated that Bima Brebes variety is a shallot variety that has high productivity and adaptability.

Table 4 proves the very significant effect of the sand fraction on the productivity of shallots in Lake Toba Catchment Area. Figure 1 shows the shallot cultivation area has a sand fraction of 69-76%, including sandy loam texture (texture category is rather coarse). In that sand fraction range, the greater the percentage of the sand fraction, the higher the productivity. Bima Brebes variety showed an increasing positive linear productivity pattern, similar to the Samosir variety. [26] stated that there is a positive correlation between the percentage of sand and *Allium* production. Land with a sufficient percentage of sand fraction which has good aeration, the soil is more porous and will cause optimal respiration and plant growth. If the percentage of sand is very high it can cause the production to be low, this is due to the low water capacity and available nutrient content. If the percentage of the sand fraction decreases and the clay fraction increases, it will interfere with the productivity of shallots. [24] stated that soils containing high clay fractions can interfere with shallot tuber development, resulting in small tubers.

Bima Brebes variety was proven to be able to produce as well as the Samosir variety, which is a mainstay local variety in the sandy loam texture of Lake Toba Catchment Area. Shallot crop yields in number, weight and size of tubers are influenced by environmental factors, genotype and agronomy [10]. In reality, successful shallot production is highly dependent on the selection of varieties that are suitable for cropping environmental conditions [27].

4. Conclusion

The shallot cultivation area in Lake Toba Catchment Area has a sand fraction of 69-76% (sandy loam texture), where the greater the percentage of sand fraction, the productivity of both shallot varieties will increase. The production of the shallots (Samosir and Bima Brebes) planted in the Lake Toba Catchment Area was identical for both kinds. The Bima Brebes variety can be relied upon to increase shallot production again in the Lake Toba Catchment Area.

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