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# Diversity of morphology, physiology and anatomy of different shallots tidal swamp varieties on under-saturated soil culture

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**Abstract** Water depth was not significantly different in the growth of shoots, growth percentage and plant height, and number of leaves. The growth of shoots was effect by the varieties. The fastest growing of shoots was on the varieties Bima brebes, Bauji, Manjung, and Tajuk compared to Sakato, while the slowest was on the Batu Ijo variety. Varieties of Bima Brebes, Bauji, Manjung, and Tajuk were a higher percentage of growth than those of SS Sakato and Batu Ijo varieties. Varieties Bima Brebes and Batu Ijo had the highest plant height compared to the Tajuk, SS Sakato, Bauji, and Manjung. The Bima Brebes variety produced more leaf growth than the Manjung, Bauji, Tajuk, Batu Ijo, and SS Sakato varieties. The CHL index, SPAD, and total chlorophyll did not affect the varieties. The depth of water did not affect SPAD and total chlorophyll but affected the CHL index. The water depth of 30 cm was a higher CHL index than the water depth of 10 cm, but the water depth of 20 cm was similar to the 10 and 30 cm water depths. The water depth was not affected by total stomata however, the varieties were affected by total stomata. The highest total of stomata was on the varieties of Bima Brebes compared to Bauji and Manjung but the varieties Tajuk, SS Sakato, and Batu Ijo were similar to Bima Brebes, Bauji, and Manjung. Bima Brebes shallot variety was the suitable variety that can be planted at a depth of 30 cm of water in tidal land with water-saturated cultivation technology based on the result of studies of morphological, physiological, and anatomical conditions.

**Keywords:** Diversity, Shallots, Varities, Tidal Swamp

## Introduction

The existence of climate change phenomena such as increased frequency of pests and diseases reduced availability of water resources and decreased soil quality have resulted in significant adverse changes to agricultural production (Williams *et al.,* 2019). This condition certainly needs to be addressed with adaptive measures. One of these adaptive steps is to utilize marginal lands and

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tidal swamp lands. Tidal swamp land was spread worldwide, as an example in Indonesia. Mukhlis *et al.* (2021) reported that out of 8.92 million ha of tidal swamp land in Indonesia, 2.80 million ha could be used for agricultural cultivation.

Even though the area of tidal land has the potential to be used as agricultural cultivation land, it turns out that on the other hand there are some drawbacks. The disadvantages of tidal land are the low availability of P and K and the high solubility of Fe, Al, and Mn, as well as the high acidity of the soil (Mukhlis *et al.,* 2021; Ghulamahdi *et al.,* 2016). These conditions can cause the growth of horticultural crops such as shallots to be suboptimal. Shallot (*Allium ascolonicum L.*) is a horticultural commodity crop that has high economic value and ranks second after tomatoes and is one of the commodities that is widely consumed by humans as a mixture of cooking spices (Fayos *et al.,* 2022).

To optimize the productivity of shallots on tidal swamp land, it is necessary to manage the land. Saturated soil culture (SSC) was one of the land management technologies in the cultivation of horticultural crops by providing water permanently, maintaining and keeping the depth constant ± 5 cm from the beginning of growth to the maturity stage so that the soil conditions become saturated and it is known that several soybean varieties can grow optimally under these conditions (Ghulamahdi *et al.,* 2016). A study of shallots on tidal swamp land has been carried out in previous studies, as was done by Mukhlis *et al.* (2021) to find out which fertilizer is effective, but the weakness of this research has only been done on one variety. The other research comparing tha varieties of shallots has also been carried out by Galingging *et al.* (2018) but only the profiling of volatile compounds and Atman *et al.* (2021) only observed the productivity. y While research related to morphological, physiological, and anatomical conditions was still scarer, even though this information is important for farmers. Mitiku and Tadesse (2018) state that farmers choose varieties to plant based on several variables, including production potential, market demand, environmental adaptability, seed accessibility, and costs. The study aimed to examine the different varieties of shallots cultivated in different levels of water in tidal swamps based on morphological, physiological, and anatomical responses.

## Materials and methods

The experiment was carried out on tidal swamps in Mulyasari Village, Tanjung Lago District Banyuasin, South Sumatera Province, Indonesia (2°32'54" S 104°39'23" E elevation 12 foot) (Figure 1), from June to September 2022. The climatic conditions in the study area indicate a wet climate. The data on rainfall distribution in 2022 in the study area was not changed. Meteorology Climatology and Geophysics Council in 2022 reported the amount of effective rainfall in July, August and September shows an amount of 100.26 mm per month.

Split Plot Design with three replications was use in this study. The main plot is water depth, which consists of treatment 1 (T1) =10 cm; treatment 2 (T2) = 20 cm; and treatment 3 (T3) = 30 cm; under saturated soil culture. The subplot is six shallot varieties, consisting of varieties 1 (V1) = Bima Brebes; varieties 2 (V2) = Bauji; varieties 3 V3 = Manjung; varieties 4 (V4) = Tajuk; varieties 5 (V5) = SS Sakato; and varieties 6 (V6) =Batu Ijo. The main area, which was 2 m by 5 m, had furrow irrigation.

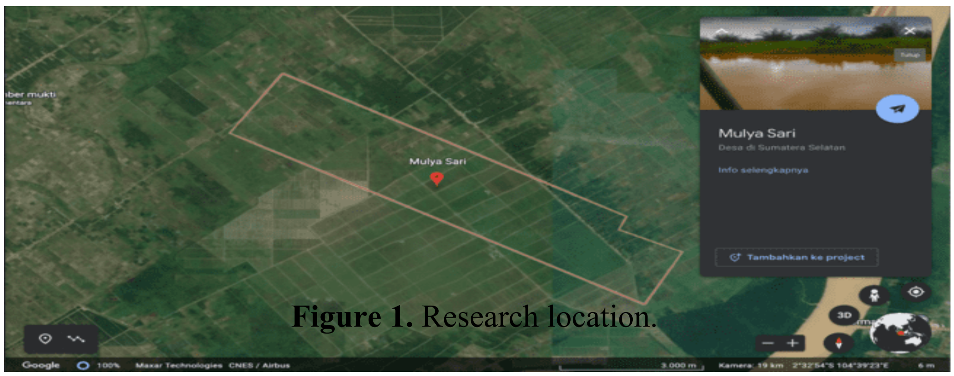


**Figure 1.** Research location.

Plots received applications of 2 tons of dolomite per hectare, 10 tons of animal manure per hectare, and fertilization: pre-plant application of urea at 47 kg/ha, ZA at 100 kg/ha, SP-36 at 311 kg/ha, and KCl at 56 kg/ha. Then, 2 months after planting (MAP), fertilization with urea at 93 kg/ha, ZA at 200 kg/ha, and KCl at 112 kg/ha was done. At 5 WAP, fertilization was done with urea at 47 kg/ha, ZA at 100 kg/ha, and KCl at 56 kg/ha.The primary plot is water depth, with a planting distance of 10 cm x 15 cm and a population of 666.666 plants/ha. The following variables were observed: plant height, growth pattern, percentage of growth, number of leaves.

The CHL Index, SPAD, chlorophyll a, chlorophyll b, and, Total chlorophyll a and b, and stomata was measured using atLEAF CHL PLUS. Soil texture was determined by the pipette method. Soil acidity (pH) was determined by extracting 1:5 using $H_2O$ and KCl. C-organic was determined by the Walkley and Black method. N was determined by the Kjeldahl method. $P_2O_5$ was determined by the Bray I method. $K_2O$ was determined by the Morgan method. Cations and micronutrients using the AAS method, and CEC using the titration method.

The soil was used media for study containing Al-dd content of 6.57 cmol (+)/kg then Fe 389 ppm. An organic C content of 3.30% and a pH value was 4.35. The base saturation value of 15.56% is included in the moderate category. $Al^{3+}$ content is very high, namely 6.57 cmol (+)/kg. The Ca cation exchange rate was low, K was moderate, but the Na and Mg cation exchange rates were high. High cation exchange capacity and low base saturation were found. Soil texture was dusty loam with a composition of 1.48% sand; dust 46.05 %; and clay 52.47%.

The data were analyzed by means of variance at the 5% level and if from the analysis of variance, the value of F 0.05 < F, the treatment The Duncan Multiple Range Test (DMRT) was performed at the = 5% level and using SAS version 9.0, quantitative data are displayed in a box plot. Qualitative characters are introduced by photo documentation.


**Figure 2.** A= **c**ondition of land flooded at high tide, B= channel depth of 30 cm, C= channel depth of 20 cm, D= Channel trenches that have filled water at high tide, E= field conditions after light tillage, F= conditions of land planted with shallot plants with SSC method In the Tidal Swamp

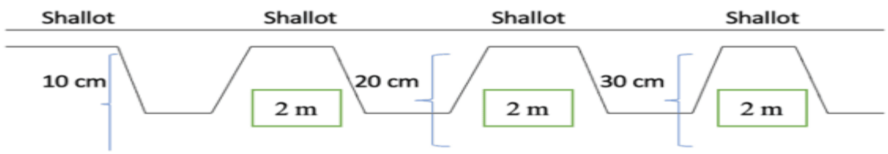


**Figure 3.** Size of the bed and the trench in saturated soil culture

## Results

### *Morphological condition*

Morphological observations carried out in this study included the growth of shoots, growth patterns, growth percentages, plant heigh and leaves number of six types of shallots at various depths of the different water-saturated cultivation on tidal swamp lands. The observation changed in the condition of shallot bulbs start on the vegetative phase of 0-7 DAP, and 14-21 DAP, at the vegetative growth stage of a maximum of 28-42 DAP until the maturation phase.

Water depth was not significantly different on growth of shoots, growth percentage and plant heigh and number of leaves. The growing of shoots was effect by the varietes (Table 1). The fastest growing of shoots was on the varieties Bima brebes, Bauji, Manjung and Tajuk compared to Sakato, while the slowest was on the Batu Ijo variety (P>0.05). The growth pattern of shallot varieties with water-saturated cultivation in tidal lands is quite good based on the form of roots, stems, and leaves (Figure 4). All varieties of shallots form a reasonably good growth pattern however, the growth of SS Sakato and Batu Ijo varieties was relatively slow compared to the other varieties.

**Table 1.** Growth of shoots (day)

| Variety | Water depth (cm USS) | | |
|---|---|---|---|
| | 10 cm | 20 cm | 30 cm |
| Bima Brebes | 6.0cd | 5.6cd | 5.0d |
| Bauji | 6.3c | 6.3c | 5.3cd |
| Manjung | 6.3c | 5.6cd | 5.3cd |
| Tajuk | 5.6cd | 6.33c | 6.3c |
| SS Sakato | 12.00a | 12.66a | 10.33b |
| Batu Ijo | 9.6b | 10.00b | 10.33b |

[a,b,c,d]: The different letter in columns significantly different between varieties (P>0.05).

The result of growth percentage was affected by the varieties. Varietes of Bima Brebes, Bauji, Manjung and Tajuk were higher percentage of growth (P>0.05) than those of SS Sakato and Batu Ijo varieties (Table 2).

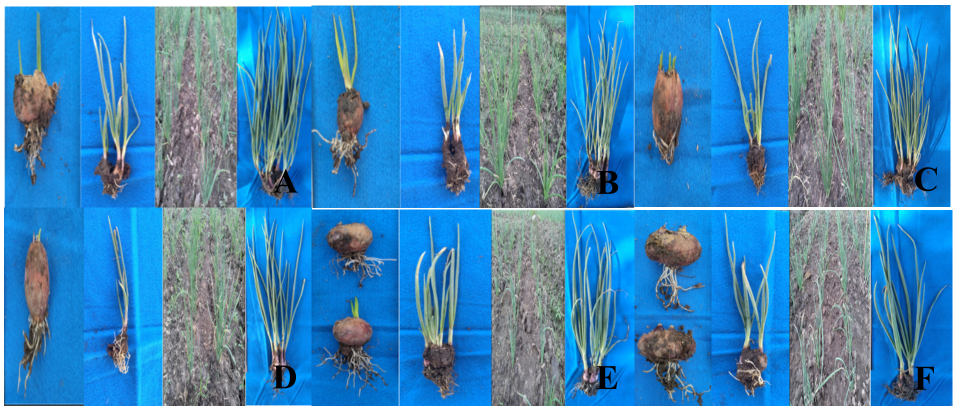


**Figure 4.** Growth pattern of six shallot varieties: A = Bima Brebes; B = Bauji, C = Manjung; D = Tajuk; E = SS Sakato; F = Batu Ijo

**Table 2.** Growth percentage (%)

| Varieties | Water depth (cm USS) | | |
|---|---|---|---|
| | **10 cm** | **20 cm** | **30 cm** |
| Bima Brebes | 98.39a | 98.33a | 99.63a |
| Bauji | 99.13a | 99.13a | 98.88a |
| Manjung | 98.52a | 99.13a | 98.76a |
| Tajuk | 98.76a | 99.14a | 98.76a |
| SS Sakato | 40.49c | 38.88c | 36.42c |
| Batu Ijo | 65.06b | 60.49b | 61.97b |

[a,b,c]: The different letter in columns significantly different between varieties (P>0.05).

The height and the number of leaves was affected by the varieties (Table 3). Varieties Bima Brebes and Batu Ijo had the highest plant height compared to the Tajuk, SS Sakato, Bauji, and Manjung had lower plant heights (P>0.05). Based on the parameter of the number of leaves from an average of 1-5 WAP, the Bima Brebes variety produced more leaf growth than the Manjung, Bauji, and Tajuk varieties meanwhile, the Batu Ijo and SS Sakato varieties produced the least number of leaves (P>0.05). Growth in number of leaves stopped at 5 WAP in all varieties.

### *Physiological condition*

The physiological condition of shallots in this study was based on the observation of CHL index, SPAD, and total chlorophyll (Table 4). The varieties were not affected the CHL index, SPAD, and total chlorophyll. The depth of water did not affect SPAD and total chlorophyll but was affected the CHL index. The water depth of 30 cm was a higher CHL index than the water depth of 10 cm, but the water depth of 20 cm was similar to the 10 and 30 cm water depths (P>0.05).

**Table 3.** Plant height and leaves number

| Variable | Age (WAP) | Variety | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bima Brebes | Bauji | Manjung | Tajuk | SS Sakato | Batu Ijo |
| Plant Height (cm) | 1 | 5.66a | 5.29bc | 4.14c | 5.52ab | 2.48d | 2.41d |
| | 2 | 15.82a | 14.26a | 14.82a | 13.63ab | 11.55b | 14.36a |
| | 3 | 22.61a | 21.05ab | 21.06ab | 19.57bc | 17.22c | 21.82ab |
| | 4 | 29.62a | 24.18bc | 25.16bc | 23.24c | 22.55c | 26.61b |
| | 5 | 31.57a | 27.61bc | 27.49bc | 27.51bc | 26.52c | 29.68ab |
| | 6 | 32.94a | 28.74b | 28.74b | 29.29b | 27.83b | 30.53ab |
| | average | 23.03 | 20.18 | 20.23 | 19.79 | 18.02 | 20.90 |
| Leaves Number (pieces) | 1 | 5.51a | 6.22a | 6.38a | 5.30ab | 4.24b | 4.21b |
| | 2 | 8.33ab | 8.70a | 8.80a | 7.45ab | 6.90b | 7.44bc |
| | 3 | 10.77a | 10.36ab | 10.13abc | 9.45bc | 9.12c | 9.55bc |
| | 4 | 13.11a | 12.36a | 12.13ab | 11.23bc | 10.90bc | 11.22c |
| | 5 | 16.77 | 15.25 | 15.24 | 14.23 | 13.57 | 14.00 |
| | average | 10.89 | 10.57 | 10.54 | 9.53 | 8.95 | 9.28 |

$^{a,b,c}$: The different letter in columns significantly different between varieties (P>0.05).

**Table 4.** CHL index, SPAD and total chlorophyll

| Treatments | | CHL Index | SPAD | TotCH(ug cm$^{-2}$) |
|---|---|---|---|---|
| Water depth | 10 cm | 31.97b | 24.22 | 21.25 |
| | 20 cm | 40.42ab | 30.74 | 27.97 |
| | 30 cm | 42.95a | 32.77 | 29.41 |
| Variety | Bima Brebes | 35.04 | 25.50 | 22.13 |
| | Bauji | 35.64 | 26.52 | 23.04 |
| | Manjung | 38.21 | 30.25 | 27.47 |
| | Tajuk | 34.75 | 25.64 | 21.97 |
| | SS Sakato | 40.41 | 30.71 | 27.48 |
| | Batu Ijo | 46.63 | 36.82 | 35.16 |

$^{a,b,c}$: The different letter in columns significantly different between water depth (P>0.05).

### *Anatomical condition*

The anatomical condition was based on the total of stomata. The water depth was not affected on total stomata however, the varieties were affected on total stomata. The highest total of stomata was on the varieties of Bima Brebes compare to Bauji and Manjung (P>0.05) but the varieties Tajuk, SS Sakato, and Batu Ijo were similar to Bima Brebes, Bauji, and Manjung.

**Table 5.** Total stomata

| | Stomata Total | |
|---|---|---|
| Water depth | 10 cm | 16.50 |
| | 20 cm | 17.67 |
| | 30 cm | 16.61 |
| Variety | Bima Brebes | 20.00a |
| | Bauji | 14.11b |
| | Manjung | 15.7b |
| | Tajuk | 16.44ab |
| | SS Sakato | 17.88ab |
| | Batu Ijo | 17.33ab |

[a,b,c]: The different letter in columns significantly different between water depth (P>0.05).

## Discussion

The shallot varieties of Bima Brebes, Bauji, Manjung, and Tajuk growth of shoots faster, and the growth percentage, and the plant height and leaves number were higher at water depths of 10, 20, and 30 cm because they had good adaptability to lowland areas like in this study area compared to SS Sakato dan Batu Ijo. Nabilah *et al.* (2022) reported that the Sakato variety was more suitable in the highlands and could produce a production of shallots of 27.62-29.44 tons/ha. In general, the tidal area is located in the lowlands. The highest of CHL index in water depth 30 cm was becaused water availibity it the channel. High water availability helps the process of photosynthesis, water also has an important role in maintaining plant temperature, and carrying out photosynthesis and respiration. It was in accordance with the opinion of Yu *et al.* (2022) photosynthesis and plant respiration had a close relationship in regulating the carbon cycle both above and below the soil surface. The CHL index, SPAD, and total chlorophyll were the same between varieties in this study. This illustrates that the ability of shallot to carry out photosynthesis was the same between varieties, and the amount of light obtained was also the same between varieties. The amount of light has a greater influence on the ability of the shallot to carry out the photosynthesis process (Farhadi *et al.,* 2017). The chlorophyll content in shallot plants is more influenced by environmental factors compared to varieties (Hasanah *et al.,* 2022).

The highest total stomata were shown in the Bima Brebes variety. This is caused by genetic and environmental factors. Genetically, the Bima Brebes variety is generally planted in lowland areas so that it gets high light intensity. It was in accordance with Hasanah *et al.* (2022) that the total stomata in shallots was influenced by genetics, shallot that receive more light intensity tend to have high stomata values. The main function of stomata was as a place for gas exchange, such as CO2 and O2 which were needed by plants in the process of photosynthesis. It is through the stomata that plants can take in carbon dioxide from the atmosphere, water molecules were modified into hydrogen and oxygen, and through the stomata, oxygen is then released as a by-product in the atmosphere. The more stomata carry out gas exchange processes, the more plants need water (Bertolino *et al.,* 2019).

Based on the results of studies of morphological, physiological, and anatomical conditions six varieties of shallots in three different level of depth water, it can be concluded that the Bima Brebes shallot variety was the suitable variety that can be planted at a depth of 30 cm of water in tidal land with water-saturated cultivation technology.

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