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# Assessing the Impact of Farming Method in Off-Season Period on the Productivity of Shallot (*Allium cepa* L.): The Case of Low-Organic Sandy-Clay Soil

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## ABSTRACT

The low productivity of shallot 'Bima Brebes' during the rainy season contributed to increasing Indonesia's economic inflation. This study aimed to assess the sustainability of shallot cultivation in low-organic sandy clay soil during the rainy season in South Sumatera, Indonesia. The study observed the farmer group's actual shallot cultivation method. The research findings were expected to explain the phenomenon of shallot production (Cohen f2) at least 0.50 with a maximum error rate ($\alpha$) of 0.05 and a probability of making the right decisions ($1-\beta$) at least 80%. The variables included climate, soil characteristics, cultivation methods carried out by farmers, plant growth, and shallot production. The cultivated field has sufficient porosity to drain water quickly. Still, it tends to make compaction easier. The diameter of the shallot bulb produced fell into category 1 (size over 2.5 cm) by as much as 31.0%, category 2 (between 2.0-2.5 cm) by 38.0%, and category 3 (between 1.5-2.0 cm) by 17.8%. The loss caused by Fusarium disease was 20.29%. Sustainability of low disease-resistance shallot variety cultivation in low-carbon sandy clay soil during rainy seasons was possible by regulating soil humidity rather than fungicide application.

## INTRODUCTION

Other than Jakarta, provinces in Indonesia produce shallot (*Allium cepa* var. aggregatum). Java Island contributed over 68.46% of shallot production in 2019, followed by Sumatera 10.46%, and the lesser were Sunda Islands 13.68%, Sulawesi 7.15%, and the rest 0.25%. Although Indonesia has experienced an increase in shallot production this year, production in the nearly half of the provinces have declined (Statistics Indonesia, 2019). Likewise, shallot production in South Sumatera province has decreased from 14,432 quintals in 2018 to 8,191 quintals in 2020 (BPS SUMSEL, 2021b), as well as productivity from 82 quintals/ha to 62 quintals/ha (BPS SUMSEL, 2021a), indicating a problem in shallot production. The decline contributes to South Sumatera economic inflation for example 0.07% in November 2020) especially during the rainy season (BI Sumsel, 2021). The phenomenon commonly occurs in South Sumatera and various Indonesia regions, caused by farmers' propensity to cultivate shallot only in the dry season thus leading to an unbalance supply throughout the year.

There are two reasons for Indonesian farmers to cultivate shallot in the dry season. The first is decreasing water availability for plants in the dry season. It is necessary to replace cultivated plant types to mitigate an environmental impact to ensure optimum profit (Ramsden et al., 2017). Secondly, the success probability of shallot production in the dry season is relatively much higher than when planting in the rainy season (DAR *et al.*, 2020). Indonesian shallot productivity difference between dry and rainy seasons was around 0.62 t/ha or equivalent to 171,440 tons in terms of goods in 2019 (Statistics Indonesia, 2019).

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The relatively high soil moisture content in the rainy season has increased the proliferation of *Fusarium* that causes basal rot. Shallot susceptibility to *Fusarium* disease is related to using the bulb as planting material rather than the true shallot seed. This cultivation behavior indirectly inhibits the natural selection process of shallot to produce characteristics that can adapt to disease and environmental stress (Taylor et al., 2019). Conditions that exceed the ideal soil humidity for shallot cultivation are not necessarily unsuitable for planting. Certain types of shallot are known to have adequate adaptations to conditions of excess or lack of water (Wakchaure et al., 2021). Several shallot varieties with good resistance to basal rot are available (Caligiore-Gei et al., 2020; Hadiwiyono et al., 2020). Unfortunately, farmers tend to cultivate the 'Bima Brebes' variety driven by consumers' preferences (though the variety is known to be susceptible to the disease). To ensure shallot production stability in Indonesia throughout the year, controlling *Fusarium* wilt disease is essential.

Previous research showed how to manage *Fusarium* in shallot cultivation. Applying the proper fungicide on bulbs (as planting material or as harvested bulb) could reduce shallot loss (Dar *et al.*, 2020). In-furrow application of fungicides is also known to reduce *Fusarium* attack potential at the crop's growth stage. Still, it is unclear if it affects curing the *Fusarium* disease (Shi et al., 2019). Nevertheless, the effectiveness of fungicides is influenced by soil characteristics, macroclimate, and cultivation methods. Treatment modifications are required if applied elsewhere, so-called farmer mitigation of environmental changes. Shallot cultivation in the rainy season is local-specific so that the accumulative research findings can contribute to enhancing shallot cultivation. Therefore, extensive research to prevent 'Bima Brebes' loss yield in local-specific is still needed.

The study aims to explain the efforts of farmer groups in shallot cultivation using the 'Bima Brebes' variety during the rainy season, including aspects of climate and soil characteristics, shallot cultivation method, characteristics of growth and yield, disease management, and sustainability of shallot cultivation.

## MATERIALS AND METHODS

The farmer group consisted of 13 members were carried on shallot planting from December 2020 to February 2021, in which the rainy season occured at the research location (Fig. 1). Group members carried out cultivation in a cooperative manner so that there was no expenditure on labor wages. The harvest was distributed among group members. The planting site soil is classified as suboptimal soil because acidic pH. The contained organic matter (C and N) and the cation exchange capacity are relatively low. The availability of phosphorus (P) is also relatively small (Table 1). Based on soil texture, the cultivated field has sufficient porosity to drain water quickly. Still, it tends to make compaction easier because clay particles (the smoothest particles) fill the cavity more quickly. This soil structure causes the cultivated field to experience changes in water saturation more quickly.

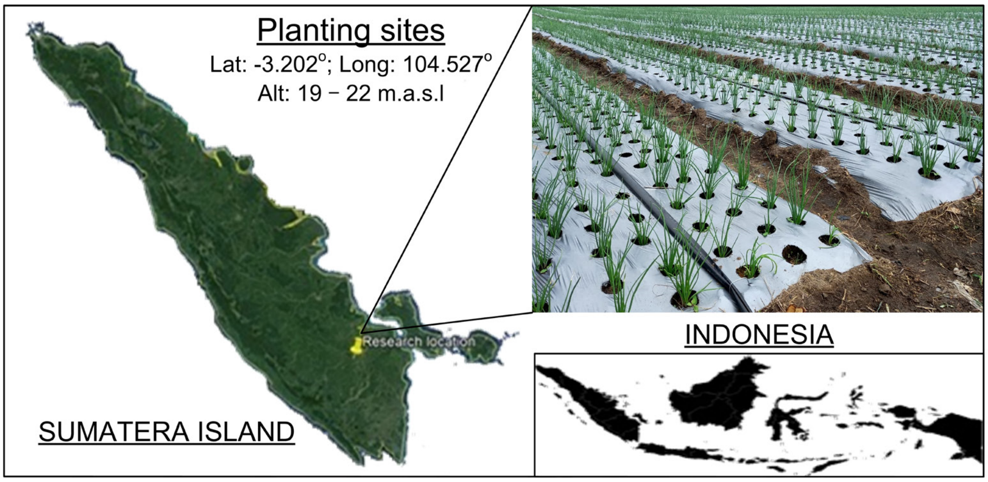


**Fig. 1.** Research location

**Table 1.** Soil conditions

| Variable | Value | Unit |
|---|---|---|
| Texture | | |
| Sand | 46.41 | % |
| Dust | 13.76 | % |
| Clay | 39.82 | % |
| Organic matter | | |
| Carbon (C) | 5.01 | % |
| Nitrogen (N) | 0.21 | % |
| C/N Ratio | 23.46 | - |
| pH | 4.69 | |
| Cation exchange | 13.71 | cmol/kg |
| Natrium (Na) | 0.04 | cmol/kg |
| Calcium (Ca) | 1.48 | cmol/kg |
| Magnesium (Mg) | 0.30 | cmol/kg |
| Kalium (K) | 0.08 | cmol/kg |
| $P_2O_5$ | 32.6 | ppm |

Land preparation was carried out by cutting the weeds using machetes and turning over the soil using a tractor. The farmers added 30 t/ha of manure and 0.3 t/ha of NPK fertilizer to enrich the soil. The planting sites with a dimension of 40 m long by 1 m wide by 20 cm high. The interval between the mounds was 30 cm. After two weeks, the farmer used mulch (plastic) to cover the mound. The planting site was around 1.15 ha, with the number of planting holes reaching 327,000 units. The planting site was divided into three experimental zones based on times to plant. The D0 was the zone where the planting material bulbs (PMB) were planted immediately after the mulch ready. The D7 and the D14 were zones where the PMB were planted a week and two weeks after the mulch ready, respectively. The farmer used PMB of the 'Bima Brebes' variety with a blue label (growing capability of 90%). The PMB visually in a good condition (not rotten) and had a sufficient dormancy period. Around one-third of the top of PMB was cut before being dressed with a bacteria growth stimulant, and sowed a day later in a planting pattern of 20 cm long and 15 cm wide.

Weeding was carried out two to three times a week. The application of fertilizer was done several times, i.e., at 14 days after sowing (DAS) using 0.20 t/ha of ZA and 15 t/ha of KCl; at 21 DAS using 0.30 t/ha of NPK; and, at 28 and 35 DAS using 0.30 t/ha of ZA and 0.20 t/ha of KCl. The farmer utilized contact and systemic fungicides to treat *Fusarium* wilt disease during the growing stages, yet none of the fungicides were used to dress the PMB. Several fungicides were applied to prevent the disease once a week started from 14 DAS. The active compounds of fungicides included chlorothalonil, ziram, difenoconazole, azoxystrobin, mancozeb, or propineb. Plant watering is done twice a day: in the morning and evening using a dripping method. The harvest was performed at 60 DAS.

The research findings were expecting to explain the phenomenon of shallot production (Cohen $f^2$) at least 0.50 with a maximum error rate ($\alpha$) of 0.05 and a probability of making the right decisions ($1-\beta$) at least 80%. Fifteen shallot clumps within the plant rows in each zone are selected randomly. The quantitative data was analyzed and interpreted using multiple linear regression (1):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \text{ ..........................1)}$$

Where: y = the shallot yield (g); $\beta_{0...3}$ = the constant or the coefficient of respectively variable; $x_1$ = the number of leaves (leaf); $x_2$ = the plant height (cm); $x_3$ = the sick-leaf proportion (%).

The in-depth-interviews method was carried to obtain qualitative data as a complement to the quantitative approach. The variable descriptions, measurement method, and unit of measurement values were presented in Table 2.

## RESULTS AND DISCUSSION

The monthly rainfall during the study was 237 mm (Medium intensity) and was categorized as Normal according to MCGA (2021). The observed growth and yield of shallot can reflect the effects of the rainy season. Shallot clumps grew relatively well as indicated by the increase of height and the number of bulbs. Not all PMB produced other bulbs. Rotten clumps showed recovery after being treated. According to the proportion, the number of clumps with rotten bulbs was about one-fifth, but it was less than 10% of bulb units. The diameter of the formed bulbs that falled into category 1 (size over 2.5 cm) was as much as 31.0%, category 2 (between 2.01-2.5 cm) was 38.0%, and category 3 (between 1.5-2.0 cm) 17.8%. The rest did not match the quality category (Table 3).

Planting site conditions are relatively unsuitable for optimum shallot growth in terms of pH, soil texture, and nutrient availability (Sutardi et al., 2022), while other parameters are considered suitable. In general, the applied fertilizer can improve soil quality by paying attention to nutrient mineral accumulation potential. Too high N and P levels in the soil are known to negatively correlated with the dry weight and the quality of the shallot bulbs produced (Souza et al., 2021).

Compared to the typical characteristics of the 'Bima Brebes' variety, 29.17% of the clumps had less-performed tillers while the plant height exceeded from the standard in the range of 10 cm. The number of leaves is in line with the standard (14-50). Based on the Indonesian National Standard SNI-3159:2013, the produced shallot bulbs can be categorized in Class 1 of quality classification (maximum damage is 10%) with the size category in Code 2 (NSA, 2013). The results showed that the growth in height and number of leaves per clump of the 'Bima Brebes' variety cultivated in the study was relatively higher than other shallot varieties. The plant height and number of leaves for the varieties of Lansuna and Trisula were 26.40 to 34.30 cm and 25.85 to 30.89 leaves (Tandi et al., 2021).

The study found similar results in terms of fresh weight and the number of bulbs produced. The fresh weight and the number of bulbs of shallot varieties Lembah Palu cultivated in Central Sulawesi were around 52.52 g and 5.71 bulbs (Lasmini et al., 2022). The plant height in this study showed a more significant increase at 28 DAS than the 'Bima Brebes' cultivated in highland South Sulawesi (40 cm vs. 31.94 cm) (Idhan et al., 2023). The equivalent diameter of bulbs is also relatively bigger compared to the bulb diameter of the 'Bima Brebes' harvested from North Sulawesi province, i.e., 1.96 cm (Tandi et al., 2021).

The planting area ratio attacked by *Fusarium* disease observed on February 18, 2021, was 20.81% and had increased by 2.16 times on February 27, 2021 (Fig. 2). The infected plants displayed physical characteristics of yellowish leaf color and rotted at the bulb base, which probably caused by *Fusarium oxysporum* (Fo). The disease distribution pattern in the A-side is relatively parallel to the water flow and evenly distributed. In contrast, healthy rows as a separator exist on the B-side.

**Table 2.** Variables description

| No | Variable | Measurement Method | Unit |
|---|---|---|---|
| 1 | Plant height | Measured at 28 and 42 days after sowing | cm |
| 2 | Number of healthy and sick leaves | Counted at 28 and 42 days after sowing | leaf |
| 3 | Bulb wet weight | Weighed at harvest day | g |
| 4 | Bulb length | Measured at harvest day | mm |
| 5 | Bulb diameter | Measured at harvest day | mm |
| 6 | Number of bulbs | Number of bulbs at harvest day | bulb |

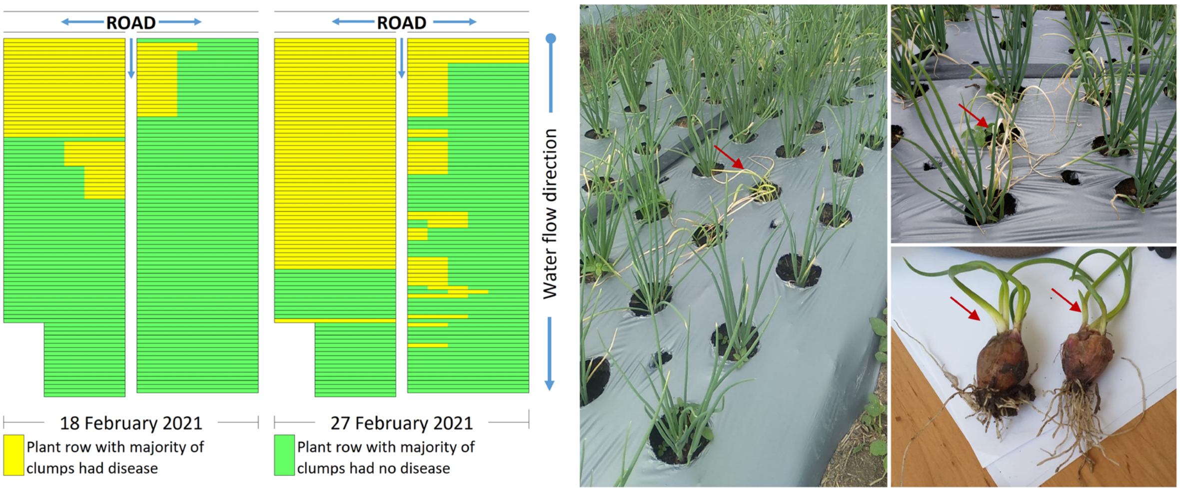
**Table 3.** Characteristics of shallots growth and cultivation yield

| Variable | Value | Variable | Value | |
|---|---|---|---|---|
| | | | 28 DAS | 42 DAS |
| Bulb fesh weight/clump (g) | 57.71 | Plant height (cm) | 40.71 | 44.13 |
| Bulb fresh weight (g) | 8.73 | Number of leaves (leaf) | 31.48 | 30.48 |
| Number of bulbs/clumps (bulb) | 7.54 | Number of bulbs/clumps (bulb) | 6.36 | 6.80 |
| Bulb equivalent diameter (cm) | 2.31 | Infected leaves proportion (%) | 12.80 | 11.75 |
| Bulb length (cm) | 3.81 | | | |
| Rotted bulb proportion (%) | 6.63 | | | |
| Rotten clumps bulbs at harvest day (%) | 20.8 | | | |
| Recovered clumps (%) | 41.38 | | | |

The increases in volatile organic compounds emissions suspected from organic fertilizers (cow dung) decomposition used during land preparation (Potard et al., 2017) or produced by *Fusarium oxysporum* f.sp. *cepae* activity, which is a shallot pathogen (Wang et al., 2019). The subspecies of Fo that commonly causes wilt in Shallot is *Fusarium oxysporum.* f.sp. *cepae*. Other species of the genus *Fusarium* that also can be the causal agents include *F. solani*, *F. culmorum, F. proliferatum* (Jahedi et al., 2019), *F. falciforme*, and *F. brachygibbosum* (Tirado-Ramirez et al., 2021). Fo disease attacks shallot plants starting from a bulb phase in storage and infects plants in the field (Cramer, 2000; Tirado-Ramirez et al., 2021). Based on the speed of expansion of fields affected by disease and their distribution pattern, the disease spread is assisted by wind and water flow (Gonsalves & Ferreira, 1993).

The application of fungicides seemed to reduce the disease severity but could not prevent its spread. Chlorothalonil application is known to inhibit fungal growth (Du et al., 2020). Fungicide with mancozeb inhibited the growth of fungus and mycelia (Gonzalez et al., 2020), whereas propineb/antracol reduced disease severity in ratios varying from 10.9 to 77.8% (Bektas & Kusek, 2021). Azoxystrobin also could reduce Fo attacks on plants (Gxasheka et al., 2020). Aside from chemical control, the farmer also physically removed infected plants and weeds around clumps. Nevertheless, all combined efforts to control the disease, including the apllication of fertilizer, gave a positive result, indicated by the plant recovery of 41.38% of the symptomatic plants (Table 3). Thus, this finding showed an evidence to counter Indonesian farmer beliefs that the infected shallot plants could not be recovered. Indeed, this finding is in line with Riaz et al. (Riaz et al., 2020), which showed that reasonable recovery could happen depending on time to response. If the farmers soaked the bulbs before planting with ziram or tebuconazole, the emergence of disease would be prevented (Sintayehu et al., 2011; Shershneva et al., 2019), and the yield loss could probably be reduced more.

The linear regression model using the variables of clump height, numbers of strands, and the proportion of infected leaves at 28 DAS did not explain the shallot production (sig. of model >0.05). At 42 DAS, the model could explain 37.2% of shallots production with an effect size of 0.592 (sig. of model <0.05). The linear regression equation was The proportion of infected leaves had differentiated the amount of shallot production significantly. An increase of 1% of infected plates reduced shallot production by 1.25 g. Assumed that the proportion of infected leaves since 42 DAS until the harvest period had not changed; there was a potential loss of 352.5 g or 20.29% of the possible production. The loss is relatively similar to previous research in Canada, which was around 20% (Bunbury-Blanchette & Walker, 2019) or 42 to 55% for the 'Bima Brebes' variety precisely (Hadiwiyono et al., 2020).



(a)

(b)

**Fig. 2.** (a) Disease spread pattern; (b) *Fusarium* wilt symptom found in the field

If the number of planting holes that failed to harvest is proportional to the area of land affected by the disease, there would only be 0.515 ha that produced 5 tons of fresh shallots, equivalent to 4 tons of dry shallots. The estimation is close to the actual harvest weight. Decreases in shallot quality had happened in the storage due to shallots decay and resulted the selling price to vary in ranges of IDR 10,000 to IDR 30,000 per kg. The final income obtained by farmers was IDR 80,000,000.

The shallot productivity by using the total field area reaches 2.67 tons dry shallots/ha. When the actual harvested area was considered (0.515 ha), the productivity value would be 7.77 tons dry shallots/ha, or 78.5% of the maximum potential (Kementan, 1984). The R/C Ratio is more than one, which indicates that shallot cultivation is economically feasible even in the rainy season (Table 4). However, when the calculation was based on the monthly income per farmer, it will result in a lower monthly payment than the regional minimum wage level. The payment would increase through proper land management efforts, ensuring that the seeds are healthy and proper management with pest and plant disease problems.

The findings showed the economic feasibility of shallot cultivation in rainy seasons from an investment perspective could improve the farmers' income if pests and diseases were well managed. The findings indicated that the success of shallot cultivation in the rainy season was related to *Fusarium* wilt disease control. The genus *Fusarium* is abundant in soil. The Fo symbiosis with plant roots is pathogenic, known as the *Fusarium oxysporum* species complex (FOSC). Fo is not always harmful, and its benefits are plant-specific. In saline soil, the presence of Fo can reduce the negative impact of NaCl on wheat growth (Elgharably & Nafady, 2021) but increase the potential for disease in chickpeas (Maharshi et al., 2021). Fo is controlled through various approaches depending on soil conditions and cultivation systems, either chemical-physically, biological agents, or synthetic approaches (Sun et al., 2021). At least three stages are needed to control Fo. The first stage is to reduce the population by preventing reproduction, killing existing ones, and preventing Fo entry from the external media into the soil. The second is maintaining the balance of soil microorganisms. The third is to regulate the types of cultivated plants known or have the potential to host Fo.

Fo reproduces by several types of spores, in the form of chlamydospores, microconidia, or macroconidia. The chlamydospores are the most extended surviving form in soil (Taylor et al., 2019). Fo spores can develop in various conditions, but optimum maturation occurs at temperatures of 20-25$^{o}$C with soil humidity of at least 85% (Manstretta & Rossi, 2016; Punja, 2021). Therefore, to prevent spore maturation, it is necessary to control soil moisture by improving the soil structure, including its organic content, and using the correct mulch type. Reduction of the non-spore Fo population can do using chemicals (Chang et al., 2021) and biological agents (Khan et al., 2021), but not at the same time. The use of fungicides was carried out at least four weeks before *Trichoderma* sp. application. This time interval is known not to affect the population development of *Trichoderma* sp. (McLean et al., 2012). *Trichoderma* has good reproductive speed and produces toxins that inhibit Fo.

**Table 4.** Economic feasibility

| **Cost (C)** | | **Revenue (R)** | |
|---|---|---|---|
| **Items** | **Nominal (IDR)** | **Items** | **Nominal (IDR)** |
| - Seeds | 34,500,000 | - Sales income | 80,000,000 |
| - Fertilizer | 7,370,000 | | |
| - Pest and disease control material | 5,990,000 | | |
| - Land rent | 500,000 | | |
| - Fixed cost and depreciation | 301,500 | | |
| Total | 48,661,500 | | 80,000,000 |
| - Benefits (B) | | | 31,338,500 |
| - R/C ratio | | | 1.65 |
| - Monthly income per person (IDR) | | | 1,205,326 |
| - Monthly income per person if the crop disease is controlled properly | | | 3,507,634 |

The next step to reduce Fo's population is by avoiding the entry of Fo into cultivated land. Fo can spread on agricultural land through the use of immature cow manure. The Fo source of cow dung comes from feed contaminated by Fo (Dandapat et al., 2011).

Due to its abundance, Fo is impossible to eradicate from the ground completely. Soil microorganism balance has an essential role in controlling disease caused by Fo. The intensive short-lived commodity cultivation system that were carried out continuously has degraded soil microorganisms quality (Grilli et al., 2021). It is necessary to regulate cultivated plants types periodically or through the polyculture system to minimize Fo attacks (Gao et al., 2020). However, it is necessary to pay close attention to the rotation or the type of plant used. Fo is known as a cross-plant-species-inoculated microorganism (Sampaio et al., 2021).

It is necessary to take the following steps to control Fo: (1) Providing annual shade crops in the field (Souza et al., 2021) with attention to their effect on light intensity. The root system of shade plants can improve soil structure and, in the long run, improve soil organic matter content; (2) Using mulch on time (according to the season). The primary purpose use mulch is to regulate soil moisture, not to prevent weeds from growing. Mulch made from organic (non-plastic) allows natural soil moisture regulation and is better than plastic mulch; (3) Rotating cultivated plants and apply polyculture. The first step is to collect data on planting plans from farmers who are farming in the area; (4) Implementing a clean production cycle, namely by educating farmers to recognize Fo contamination sources and carry out Fo control that does not damage the balance of soil microorganisms.

## CONCLUSION

Sustainability of low disease-resistance shallot variety cultivation in low-carbon sandy clay soil during rainy seasons was possible when *Fusarium* disease was controlled adequately. The key element to do so is regulating soil humidity, i.e., using annual shading plants rather than plastic mulch and ensuring the mound is parallel to water flow, besides fungicide application. The root system of the annual plant would prevent sandy clay from erotion.

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## REFERENCES

Bektas, I. & Kusek, M. (2021). Biological control of onion basal rot disease using phosphate solubilising rhizobacteria. *Biocontrol Science and Technology*, 31(2), 190–205. https://doi.org/10.1080/09583157.2020.1839381

BI Sumsel. (2021). *Laporan Perekonomian Provinsi Sumatera Selatan Februari 2021*. Palembang. https://www.bi.go.id/id/publikasi/laporan/lpp/Documents/Laporan-Perekonomian-Provinsi-Sumatera-Selatan-Februari-2021.pdf

BPS SUMSEL. (2021a). *Luas Panen Sayuran (Hektar) 2018-2020*, *Hortikultura*. https://sumsel.bps.go.id/indicator/55/404/1/luas-panen-sayuran.html.

BPS SUMSEL. (2021b). *Produksi Sayuran (Kuintal) 2018-2020*, *Hortikultura*. https://sumsel.bps.go.id/indicator/55/406/1/produksi-sayuran.html.

Bunbury-Blanchette, A. L. & Walker, A. K. (2019). Trichoderma species show biocontrol potential in dual culture and greenhouse bioassays against Fusarium basal rot of onion. *Biological Control*, 130, 127–135. https://doi.org/10.1016/j.biocontrol.2018.11.007

Caligiore-Gei, P. F., Ciotti, M. L., Valdez, J. G. & Galmarini, C. R. (2020). Breeding onion for resistance to Fusarium basal rot: comparison of field selection and artificial inoculation. *Tropical Plant Pathology*, 45(5), 493–498. https://doi.org/10.1007/s40858-020-00351-y

Chang, Y., Zhong, W., Liang, J., Zhang, A. & Lin, Y. (2021). Polydimethylsiloxane-polymethacrylate block copolymers containing quaternary ammonium salts against *Fusarium oxysporum* f. sp. *cubense* race 4 in soil: Antifungal activities and pot experiments. *Reactive and Functional Polymers*, 160, 104848. https://doi.org/10.1016/j.reactfunctpolym.2021.104848.

Cramer, C. S. (2000). Breeding and genetics of Fusarium basal rot resistance in onion. *Euphytica*, 115(3), 159–166. https://doi.org/10.1023/A:1004071907642

Dandapat, P., Nanda, P., Bandyopadhyay, S., Kaushal, A. & Sikdar, A. (2011). Prevalence of Deg Nala disease in eastern India and its reproduction in buffaloes by feeding *Fusarium oxysporum* infested rice straw. *Asian Pacific Journal of Tropical Medicine*, 4(1), 54–57. https://doi.org/10.1016/s1995-7645(11)60032-1.

Dar, A. A., Sharma, S., Mahajan, R., Mushtaq, M., Salathia, A., Ahamad, S., Sharma, J. P. (2020). Overview of purple blotch disease and understanding its management through chemical, biological and genetic approaches. *Journal of Integrative Agriculture*, 19(12), 3013–3024. https://doi.org/10.1016/S2095-3119(20)63285-3.

Du, X.-J., Peng, X.-J., Zhao, R.-Q., Zhao, W.-G., Dong, W.-L. & Liu, X.-H. (2020). Design, synthesis and antifungal activity of threoninamide carbamate derivatives via pharmacophore model. *Journal of Enzyme Inhibition and Medicinal Chemistry*, 35(1), 682–691. https://doi.org/10.1080/14756366.2020.1729144.

Elgharably, A. & Nafady, N. A. (2021). Inoculation with *Arbuscular mycorrhizae*, *Penicillium funiculosum* and *Fusarium oxysporum* enhanced wheat growth and nutrient uptake in the saline soil. *Rhizosphere*, p. 100345. http://dx.doi.org/10.1016/j.rhisph.2021.100345.

Gao, X., Li, K., Ma, Z., Zou, H., Jin, H. & Wang, J. (2020). Cucumber Fusarium wilt resistance induced by intercropping with celery differs from that induced by the cucumber genotype and is related to sulfur-containing allelochemicals. *Scientia Horticulturae*, 271, p. 109475. https://doi.org/10.1016/j.scienta.2020.109475.

Gonsalves, A. K. & Ferreira, S. A. (1993). *Fusarium oxysporum*, *Crop Knowledge Master*. http://www.extento.hawaii.edu/kbase/crop/Type/f_oxys.htm

Gonzalez, M. F., Magdama, F., Galarza, L., Sosa, D. & Romero, C. (2020). Evaluation of the sensitivity and synergistic effect of *Trichoderma reesei* and mancozeb to inhibit under in vitro conditions the growth of *Fusarium oxysporum*. *Communicative & Integrative Biology*, 13(1), 160–169. https://doi.org/10.1080/19420889.2020.1829267.

Grilli, E., Carvalho, S. C. P., Chiti, T., Coppola, E., D'Ascoli, R., La Mantia, T., Marzaioli, R., Mastrocicco, M., Pulido, F., Rutigliano, A., Quatrini, P. & Castaldi, S. (2021). Critical range of soil organic carbon in southern Europe lands under desertification risk. *Journal of Environmental Management*, 287, p. 112285. https://doi.org/10.1016/j.jenvman.2021.112285.

Gxasheka, M., Wang, J., Gunya, B., Mbanjwa, V., Tyasi, T. L., Dlamini, P. & Gao, J. (2020). In vitro effect of some commercial fungicides on mycelial growth of Fusarium species causing maize ear rot disease in China. *Archives of Phytopathology and Plant Protection*, pp. 1–13. https://doi.org/10.1080/03235408.2020.1844531.

Hadiwiyono, H., Sari, K. & Poromarto, S. H. (2020). Yields losses caused by basal plate rot (*Fusarium oxysporum* f.sp. *cepae*) in some shallot varieties, *Caraka Tani. Journal of Sustainable Agriculture*, 35(2), 250. DOI: http://dx.doi.org/10.20961/carakatani.v35i2.26916.

Idhan, A., Syam'un, E. & Riyadi, M. 2023. Production of Botanical Seeds and Shallot Boobs with Vernalization and Giberrylin (GA3) Treatment in Highland Areas, *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *12*(1), 201-211. https://doi.org/10.23960/jtep-l.v12i1.201-211.

Jahedi, A., Safaie, N. & Goltapeh, E. M. (2019). *Fusarium avenaceum* and *Fusarium crookwellens* cause onion basal rot in Iran. *Archives of Phytopathology and Plant Protection*, 52(9–10), 953–968. https://doi.org/10.1080/03235408.2019.1672913.

Kementan. (1984). *Bima Brebes*, *Sistem Informasi Database Varietas Tanaman*. http://aplikasi.pertanian.go.id/varietas/tamu/utama.asp

Khan, M. A., Khan, S. A., Waheed, U., Raheel, M., Khan, Z., Alrefaei, A. F. & Alrefaei, F., Alkhamis, H. H. (2021). Morphological and genetic characterization of *Fusarium oxysporum* and its management using weed extracts in cotton. *Journal of King Saud University - Science*, 33(2), 101299. https://doi.org/10.1016/j.jksus.2020.101299.

Lasmini, S. A., Idham, I., Haji Nasir, B., Pasaru, F., Lakani, I. & Khasanah, N. 2022. Agronomic performance of shallot (*Allium cepa* L. Var. Aggregatum) under different mulch and organic fertilizers, *Tropical and Subtropical Agroecosystems*, *25*(2), 1-9. https://doi.org/10.56369/tsaes.4140.

Maharshi, A., Rashid, M. M., Teli, B., Yadav, S. K., Singh, D. P. & Sarma, B. K. (2021). Salt stress alters pathogenic behaviour of *Fusarium oxysporum* f. sp. *ciceris* and contributes to severity in chickpea wilt incidence. *Physiological and Molecular Plant Pathology*, 113, p. 101602. https://doi.org/10.1016/j.pmpp.2021.101602.

Manstretta, V. & Rossi, V. (2016). Effects of temperature and moisture on development of *Fusarium graminearum* Perithecia in maize stalk residues. *Applied and Environmental Microbiology*. Edited by A. A. Brakhage, 82(1), 184–191. https://doi.org/10.1128/AEM.02436-15.

MCGA. (2021). Monthly precipitation, *Climate Analysis*. Meteorological, Climatological, and Geophysical Agency. Available at: https://www.bmkg.go.id/en.html. (Accessed: 3 March 2021).

McLean, K. L., Hunt, J. S., Stewart, A., Wite, D., Porter, I. J. & Villalta, O. (2012). Compatibility of a *Trichoderma atroviride* biocontrol agent with management practices of *Allium crops*. *Crop Protection*, 33, 94–100. https://doi.org/10.1016/j.cropro.2011.11.018.

NSA. (2013). SNI-3159 Bawang merah (*Allium cepa* var. ascalonicum). Indonesia: National Standardization Agency. http://sispk.bsn.go.id/SNI/DetailSNI/8925.

Potard, K., Monard, C., Le Garrec, J.-L., Caudal, J.-P., Le Bris, N. & Binet, F. (2017). Organic amendment practices as possible drivers of biogenic Volatile Organic Compounds emitted by soils in agrosystems. *Agriculture, Ecosystems & Environment*, 250, 25–36. http://dx.doi.org/10.1016/j.agee.2017.09.007.

Punja, Z. K. (2021). Epidemiology of *Fusarium oxysporum* causing root and crown rot of cannabis (*Cannabis sativa* L., marijuana) plants in commercial greenhouse production. *Canadian Journal of Plant Pathology*, 43(2), 216–235. https://doi.org/10.1080/07060661.2020.1788165.

Ramsden, S. J., Wilson, P. & Phrommarat, B. (2017). Integrating economic and environmental impact analysis: The case of rice-based farming in Northern Thailand. *Agricultural Systems*, 157, 1–10. https://doi.org/10.1016/j.agsy.2017.06.006.

Riaz, M., Mahmood, R., Khan, S. N., Haider, M. S. & Ramzan, S. (2020). Onion tip burn: Significance, and response to amount and form of nitrogen. *Scientia Horticulturae*, 261, p. 108773. http://dx.doi.org/10.1016/j.scienta.2019.108773.

Sampaio, A. M., Rubiales, D. & Vaz Patto, M. C. (2021). Grass pea and pea phylogenetic relatedness reflected at *Fusarium oxysporum* host range. *Crop Protection*, 141, p. 105495. http://dx.doi.org/10.1016/j.cropro.2020.105495.

Shershneva, A. M., Murueva, A. V., Zhila, N. O. & Volova, T. G. (2019). Antifungal activity of P3HB microparticles containing tebuconazole. *Journal of Environmental Science and Health, Part B*, 54(3), pp. 196–204. https://doi.org/10.1080/03601234.2018.1550299.

Shi, X., Qiao, K., Li, B. & Zhang, S. (2019). Integrated management of *Meloidogyne incognita* and *Fusarium oxysporum* in cucumber by combined application of abamectin and fludioxonil. *Crop Protection*, 126, p. 104922. https://doi.org/10.1016/j.cropro.2019.104922.

Sintayehu, A., Sakhuja, P. K., Fininsa, C. & Ahmed, S. (2011). Management of Fusarium basal rot (*Fusarium oxysporum* f. sp. *cepae*) on shallot through fungicidal bulb treatment. *Crop Protection*, 30(5), 560–565. https://doi.org/10.1016/j.cropro.2010.12.027.

Souza, M., Müller Júnior, V., Kurtz, C., dos Santos Ventura, B., Lourenzi, C. R., Lazzari, C. J. R., Ferreira, G. W., Brunetto, G., Loss, A. & Cormin, J. (2021). Soil chemical properties and yield of onion crops grown for eight years under no-tillage system with cover crops. *Soil and Tillage Research*, 208, p. 104897. https://doi.org/10.1016/j.still.2020.104897.

Statistics Indonesia. (2019). Horticultural Statistics. Jakarta, Indonesia. https://www.bps.go.id/publication/2020/08/28/5eb79ca777ce4ba7a2908a4d/statistik-hortikultura-2019.html

Sun, R.-L., Jing, Y.-L., de Boer, W., Guo, R.-J. & Li, S.-D. (2021). Dominant hyphae-associated bacteria of *Fusarium oxysporum* f. sp. *cucumerinum* in different cropping systems and insight into their functions. *Applied Soil Ecology*, 165, p. 103977. http://dx.doi.org/10.1016/j.apsoil.2021.103977.

Sutardi, Kristamtini, Purwaningsih, H., Widyayanti, S., Arianti, F. D., Pertiwi, M. D., Triastono, J., Praptana, R. H., Malik, A., Cempaka, I. G., Yusuf, Yufdy, M.P., Anda, M. & Wihardjaka, A. (2022). Nutrient Management of Shallot Farming in Sandy Loam Soil in Tegalrejo, Gunungkidul, Indonesia, *Sustainability (Switzerland)*, 14(19). doi: 10.3390/su141911862.

Tandi, O. G., Salamba, H. N., Lintang, M. & Mongan, B. (2021). Agronomic characteristics and shallot production in Tomohon city, North Sulawesi, *E3S Web of Conferences*, 306, pp. 1–6. doi: 10.1051/e3sconf/202130601035.

Taylor, A., Teakle, G. R., Walley, P. G., Finch-Savage, W. E., Jackson, A. C., Jones, J. E., Hand, P., Thomas, B., Havey, M. J., Pink, D. A. C. & Clarkson, J. P. (2019). Assembly and characterisation of a unique onion diversity set identifies resistance to Fusarium basal rot and improved seedling vigour. *Theoretical and Applied Genetics*, 132(12), pp. 3245–3264. https://doi.org/10.1007/s00122-019-03422-0.

Tirado-Ramirez, M. A., López-Urquídez, G. A., Amarillas-Bueno, L. A., Retes-Manjarrez, J. E., Vega-Gutiérrez, T. A., López Avendaño, J. E. & Lopez-Orona, C. A. (2021). Identification and virulence of Fusarium falciforme and Fusarium brachygibbosum as causal agents of basal rot on onion in Mexico, *Canadian Journal of Plant Pathology*, pp. 1–12. https://doi.org/10.1080/07060661.2021.1894241.

Wakchaure, G. C., Minhas, P. S., Kumar, S., Khapte, P. S., Meena, K. K., Rane, J., Pathak. (2021). Quantification of water stress impacts on canopy traits, yield, quality and water productivity of onion (*Allium cepa* L.) cultivars in a shallow basaltic soil of water scarce zone. *Agricultural Water Management*, 249, p. 106824. https://doi.org/10.1016/j.agwat.2021.106824.

Wang, A., Islam, M. N., Johansen, A., Haapalainen, M., Latvala, S. & Edelenbos, M. (2019). Pathogenic *Fusarium oxysporum* f. sp. *cepae* growing inside onion bulbs emits volatile organic compounds that correlate with the extent of infection. *Postharvest Biology and Technology*, 152, 19–28. https://doi.org/10.1016/j.postharvbio.2019.02.010.