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Assessment of Soil Physical Quality in Dryland Using Organic Mulch and *Trichoderma* (A Case Study on Shallot *Allium cepa* L. var. aggregatum Cultivation in Mandala Village, Rubaru Subdistrict, Sumenep Regency)

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Abstract
Shallot cultivation in Rubaru is carried out during the dry season after farmers harvest corn. Corn husk waste is utilized as organic mulch, and its effectiveness is compared to the use of bamboo leaves. *Trichoderma* is applied to accelerate decomposition. The resulting organic matter aims to improve soil texture, permeability, temperature, and pH. The objective of this study is to determine the extent to which organic mulch and *Trichoderma* influence the physical properties of the soil and the productivity of Rubaru shallots, as well as to identify farmers' responses. The research was conducted in Mandala Village using a Completely Randomized Design (CRD) and analyzed through ANOVA. The results of this study indicate that *Trichoderma* application reduced the clay percentage, thereby increasing the silt percentage, reaching 80% in treatment P4. Soil temperature showed a significant difference between treatments, with plot P4 recording 28 °C. Permeability rate was categorized as slow in plot P3 (1.54 cm/hour), although it was not significantly different among treatments. Soil pH differed significantly, with P1 recording the highest pH at 8.19. Productivity also showed a significant difference, with the highest yield recorded in treatment P4 (18.67 tons/ha). Most farmers were unaware of the use of organic mulch and showed no interest in applying it. However, 75% of farmers were aware of the benefits of *Trichoderma*, and all expressed willingness to use it.

Keywords: Rubaru Shallots, Organic Mulch, *Trichoderma*, and Soil Physical Properties

1. Introduction
Rubaru shallot is a local variety originating from Sumenep Regency. The name "Rubaru" comes from the region where this variety is cultivated, namely Rubaru Subdistrict. There are three central cultivation villages for this variety, namely Basoka, Mandala, and Karangnangka, as stated in the Appendix of the Decree of the Minister of Agriculture Number: 2525/Kpts/SR.120/5/2011. Unlike in areas such as Nganjuk, farmers in Rubaru grow shallots on drylands. During the dry season, shallots are planted after the corn harvest. At this time, corn husk waste is abundant. Farmers usually use corn husks as livestock feed or burn them. Additionally, during the dry season, bamboo leaves are also widely available. Shallot farmers in Rubaru Subdistrict have been cultivating this crop for generations, relying on traditional knowledge passed down from their parents. As a result, several farming practices are suboptimal, particularly in fertilization. Many farmers assume that the more frequently or abundantly fertilizers are applied, the better the shallot growth. However, excessive use of chemical fertilizers reduces soil organic matter, damages soil structure, degrades soil quality, and harms the environment (Melsasail *et al*., 2019) [10]. Overapplication of inorganic fertilizers, such as urea—which is highly water-absorbent—without balancing with organic inputs can deteriorate the soil's physical quality (Herdiyantoro, 2015) [5].
To restore or improve declining soil physical quality, local microorganisms such as *Trichoderma* sp. and organic mulches can be applied. The decomposition process is significantly accelerated with *Trichoderma*; without it, organic matter may take 3–4 months to break down, whereas with *Trichoderma*, the process only takes about a month (Jumadi *et al*., 2021) [7].

Although the use of some organic materials has been adopted, further research is needed to explore other locally available organic sources (Iriany *et al*., 2022) [6]. In Mandala Village, commonly available organic mulch materials include bamboo leaves and corn husks.

Organic mulch helps reduce evaporation and maintains soil permeability, thus supporting better root development in shallots (Sukmawan *et al*., 2018) [16]

Based on the background above, this study aims to investigate the improvement of soil physical properties through the application of locally available organic mulches. The research seeks to evaluate the extent to which organic mulches enhance soil physical quality and contribute to increasing shallot productivity. Additionally, the study intends to provide information and encourage farmers to utilize locally available organic materials.

2. Methods

This research was conducted in Banyuliang Hamlet, Mandala Village, Rubaru Subdistrict, in collaboration with the National Research and Innovation Agency (BRIN) and the Faculty of Agriculture, Wiraraja University, during the period of June–July 2024. The experimental plot measured 4 × 2 meters, with raised beds 30 cm in height and drainage channels 30 cm in width. The experimental method employed a Completely Randomized Design (CRD) to determine the effect of organic mulch application on soil physical properties (Putri *et al*., 2018) [13]. The materials used in this study were ground corn husks and bamboo leaves to accelerate decomposition and facilitate integration into the soil. To further speed up the decomposition process, *Trichoderma* sp. was applied. The resulting decomposed materials were expected to improve soil physical properties. Laboratory analyses were conducted to assess soil physical characteristics such as texture, permeability, and pH. Soil sampling in the field was performed using a soil ring sampler measuring 10 cm in height and 5 cm in diameter. Soil temperature was measured directly in the field using a soil thermometer (Eviati, 2009) [3]. Shallot productivity was calculated by multiplying the harvested weight per plot by the ratio of 1 hectare to the size of the experimental plot. The soil physical data were analyzed using ANOVA to evaluate and determine the significance of differences among treatment variables (Rusdiana & Fariroh, 2024) [14]. Farmers' responses were analyzed using qualitative descriptive analysis. Respondents were selected using purposive sampling based on criteria such as having long-standing experience and consistent involvement in cultivating Rubaru shallots. Data collection was carried out through questionnaires distributed to 20 out of 27 members of the Mandala Putra Farmer Group in Mandala Village, Rubaru Subdistrict, and was organized in the form of a Focus Group Discussion (FGD).

3. Results and Discussion

Results

The use of organic mulch from corn husks and bamboo leaves was chosen because both are waste materials abundantly available in the research area. Corn husks have a higher water absorption capacity due to their high fiber content, including lignin, cellulose, cyclohexanol, and ash. According to (Kusuma, 2019) [9] the fiber content in corn husks enhances water retention through internal cavities. On the other hand, bamboo leaf mulch has a smooth leaf surface and lower water absorption capacity, causing water to be released directly into the soil. The application of mulch also serves to protect the soil from the direct impact of raindrops, thereby reducing soil compaction. The experimental treatments were as follows:

P0: Control plot without mulch
P1: Bamboo leaf mulch without *Trichoderma*
P2: Bamboo leaf mulch with 300 g of *Trichoderma*
P3: Corn husk mulch without *Trichoderma*
P4: Corn husk mulch with 300 g of *Trichoderma*.

a. *Trichoderma*

In shallot cultivation, one of the most common diseases is *Fusarium* wilt, also known as moler. According to (Muliana *et al*., 2024) [11], the use of *Trichoderma* sp. as a biological control agent can suppress and manage moler disease in shallots. Additionally, with the proper dosage and in combination with existing organic matter in the soil, *Trichoderma* can enhance soil fertility. Besides organic matter, chemical residues—such as those from chemical fertilizers—must also be considered.

Trichoderma is also commonly used as a composting stimulant. It acts as a decomposer of organic compost materials by breaking down organic matter and producing nutrients beneficial to plants. The decomposition process is significantly faster when *Trichoderma* is applied; without it, decomposition may take 3–4 months, whereas with *Trichoderma*, the process may be completed in just one month. The resulting compost is often referred to as tricho-compost (Jumadi *et al*., 2021) [7].

However, laboratory tests showed zero *Trichoderma* presence in all treatment plots. This result is attributed to environmental factors and soil pH. Environmental conditions such as temperature and the presence of chemical residues may drastically reduce or even eliminate *Trichoderma* populations. High soil pH is one of the key factors affecting *Trichoderma* growth, which thrives optimally at a pH of 5 (Sulistiyono, 2017) [17].

b. Texture

The application of *Trichoderma* can accelerate the decomposition of organic mulch. Naturally, the decomposition process may take 3–4 months due to the limited availability of native decomposer microorganisms. However, the use of *Trichoderma* can shorten this period to approximately 1–2 months (Jumadi *et al*., 2021) [7]. Therefore, the combined application of organic mulch and *Trichoderma* can increase the percentage of silt texture in the soil.

Table 1: Soil Texture Test Result

Treatment	Sand (%)	Slit (%)	Clay (%)	Texture Class Result
P0	6 d	34 a	59 e	Clay
P1	2 b	57 c	42 c	Silty Clay
P2	0 a	65 d	35 b	Silty Clay Loam
P3	3 c	45 b	52 d	Silty Clay
P4	2 b	80 e	18 a	Silty Loam
Duncan's Test 5%	(*)	(*)	(*)	
Note	Values followed by different letters within the same column indicate a significant difference between treatments according to Duncan's Multiple Range Test at the 5% level. * = significantly different			

Based on the soil physical properties texture test results above, it was found that the untreated soil (P0) had a clay texture, characterized by 6% sand, 34% silt, and 59% clay. Treatment P1 exhibited a silty clay texture with 2% sand, 57% silt, and 42% clay. Treatment P2 showed a silty clay loam texture, consisting of 0% sand, 65% silt, and 35% clay. Treatment P3 also had a silty clay texture, with 3% sand, 45% silt, and 52% clay. Meanwhile, treatment P4 resulted in a silty loam texture, with 2% sand, 80% silt, and only 18% clay.

A comparison between P0 (no mulch and no *Trichoderma*) and P4 (with *Trichoderma* and organic mulch) shows a significant shift in soil texture—from clay in P0 to silty loam in P4. This is primarily due to the high percentage of silt (80%) in P4, following the application of *Trichoderma* and organic mulch (Supriyadi, 2007) [18].

c. Permeability

ANOVA results showed that soil permeability did not differ significantly among treatments. The permeability rate in plots mulched with corn husks was lower than that in plots mulched with bamboo leaves. The water-holding capacity of organic mulch also helps reduce soil evaporation, as it shields the soil surface from direct sunlight exposure.

The permeability rate in the control plot (P0) was 5.1267 cm/hour, which falls into the moderate category. Meanwhile, treatment P3, which involved the application of *Trichoderma* and corn husk mulch, showed a slow permeability rate of 1.54 cm/hour. This indicates that the combination of *Trichoderma* and organic mulch enhances the soil's water retention capacity.

Table 2: Soil Permeability Test Results

Treatment	Permeability Rate (cm/hour)
P0	5.1267
P1	2.1933
P2	2.9700
P3	1.5400
P4	2.6457
Duncan's Test 5%	ns
Note	Values followed by different letters in the same column indicate significant differences between treatments based on Duncan's Multiple Range Test at the 5% significance level. ns = not significantly

The decomposition of organic mulch improves both soil structure and permeability, thereby enhancing the soil–water–air relationship. This condition results in a permeability rate reduction of up to 50% in plots treated with organic mulch compared to plots without mulch. Such results indicate an improvement in the soil's water-holding capacity (Putrayanto, 2017) [12]

d. Soil Temperature

The soil temperature test results showed a significant difference among treatments. The recorded temperatures were as follows:

P0= 32 °C
P1= 30 °C
P2= 29 °C
P3= 29 °C
P4= 28 °C

The lowest temperature was observed in treatment P4, which combined corn husk mulch and *Trichoderma*. These results indicate that the use of organic mulch and *Trichoderma* can effectively reduce soil temperature (Suharyatun *et al*., 2023). This temperature reduction is attributed to the mulch's ability to limit the amount of solar radiation absorbed by the soil (Gulat, 2012) [4]. Shallots grow best and yield optimally, both in terms of quality and quantity, when planted in areas up to 250 meters above sea level, with temperatures ranging between 25 °C and 32 °C (Gulat, 2012) [4]. Thus, the conditions found in treatment P4 are considered ideal for shallot cultivation.

Table 3: Soil Temperature Test Result

Treatment	Temperature (℃)
P0	32 c
P1	30 b
P2	29 ab
P3	29 ab
P4	28 a
Duncan's Test 5%	*
Note	Values followed by different letters within the same column indicate a significant difference between treatments according to Duncan's Multiple Range Test at the 5% level. * = significantly different

e. Soil pH

Laboratory tests indicated that *Trichoderma* was not able to survive in the soil until the end of the planting period. One of the main contributing factors is soil pH. According to (Sulistiyono, 2017) [17], the optimal soil pH for *Trichoderma* growth is neutral. However, the pH test results showed that the soil in the study area was alkaline. Laboratory analysis revealed the following pH values:

P0= 8.22
P1= 8.195
P2= 8.22
P3= 8.96
P4= 8.3

This condition confirms that the soil is alkaline. Such alkalinity is common in Madura, as the region's soil is derived from limestone deposits, which contain high levels of calcium. As a result, soils from these deposits tend to have higher pH values (Supriyadi, 2007) [18]. ANOVA results showed a significant difference among treatments.

Table 4: Soil pH Test Result

Treatment	pH
P0	8.22 a
P1	8.195 a
P2	8.22 a
P3	8.96 b
P4	8.3 a
Uji Duncan 5%	*
Note	Values followed by different letters within the same column indicate a significant difference between treatments according to Duncan's Multiple Range Test at the 5% level. * = significantly different

The presence of organic materials that contribute to increased silt content also supports easier bulb development, as silty textures promote moderate water infiltration—faster than clay but slower than sand. This water infiltration rate is referred to as permeability. Laboratory analysis of permeability showed that P0 (control) had the highest permeability rate at 5.1 cm/hour, indicating highly permeable soil. In contrast, P3 showed the lowest rate (1.5 cm/hour), indicating denser soil with slower water infiltration. Treatments P1 (2.2 cm/hour), P4 (2.6 cm/hour), and P2 (3.0 cm/hour) were classified as having moderate permeability and demonstrated reduced water movement compared to the control. The lower permeability rates observed in these treatments also had a direct effect on reducing soil temperature.

f. Productivity

Productivity data were measured directly after harvest. ANOVA analysis showed significant differences among the treatments

Table 5: Productivity Analysis Results

Treatment	Productivity (tons/ha)
P0	11.79 a
P1	13.08 b
P2	16.78 c
P3	14.41 d
P4	18.67 e
Duncan's Test 5%	*
Note	Values followed by different letters within the same column indicate a significant difference between treatments according to Duncan's Multiple Range Test at the 5% level. * = significantly different

The productivity of shallots was calculated by dividing 1 hectare of land by the size of the plot and multiplying by the total harvested yield. Generally, shallot productivity in Rubaru ranges between 14–17 tons per hectare. The productivity results for each treatment were as follows:

P0: 11.79 tons/ha
P1: 13.08 tons/ha
P2: 16.78 tons/ha
P3: 14.41 tons/ha
P4: 18.67 tons/ha

The highest productivity was observed in treatment P4, which combined 300 grams of *Trichoderma* with corn husk mulch. This result suggests a synergistic effect between biological agents and organic mulch.

The high soil pH (alkaline) in the study area is associated with a higher clay texture percentage compared to other soil textures. Laboratory analysis confirmed that the clay fraction was more dominant than silt and sand (Supriyadi, 2007) [18]. Rubaru shallots grow optimally in soils with a crumb structure and clay-to-silt texture, which supports better root and bulb development (Kurnianingsih *et al*., 2019) [8].

g. Farmer's Response

The response of farmers to the application of *Trichoderma* and organic mulch was obtained through a focus group discussion (FGD), and was assessed based on three indicators.

The first indicator is the level of knowledge of farmers regarding *Trichoderma*, which reached 75%, or 15 out of 20 farmers. One farmer was aware of the benefits of *Trichoderma* through various sources such as colleagues engaged in cultivation in other regions. The remaining 14 farmers obtained their knowledge through the implementation of the demonstration plot for shallot cultivation. In contrast, the level of knowledge regarding organic mulch was significantly lower, with only 10% or 2 farmers understanding its benefits.

The second indicator is the attitude of the farmers, defined as their willingness or unwillingness to apply *Trichoderma* and/or organic mulch. All farmers expressed willingness to apply *Trichoderma* in shallot cultivation. However, despite the abundant availability of corn husk waste in Mandala Village, farmers were unwilling to use it as organic mulch. They believed that non-shredded corn husk mulch would hinder shallot seedling emergence. Moreover, shredding organic mulch material requires additional time and labor, which farmers considered a burden.

The third indicator is the skill level of farmers. The percentage of farmers capable of applying *Trichoderma* properly was 75%, with 5 farmers successfully implementing it in their shallot cultivation. The application of *Trichoderma* was reported to increase soil moisture in cultivated areas. When applied at the appropriate dosage, *Trichoderma* is able to effectively colonize plant roots, supporting plant health and growth.

Discussion

Mandala Village is an area where dryland (Tegalan) is more extensive than paddy fields, covering approximately 1,346.86 hectares. During the rainy season, maize is the primary crop cultivated in this region (BPS, 2021).

Meanwhile, Rubaru shallots are generally planted on dryland after the maize harvest. The agricultural residues from maize are then utilized as organic mulch for shallot cultivation. The application of organic mulch can suppress weed growth, reduce soil water evaporation—thereby conserving irrigation water—lower soil temperature, and increase crop yield (Banjarnahor, 2022) [1]. Analytical results show that soil temperature in the control plot without mulch (P0) was 32 °C, which is higher compared to the plot using corn husk mulch (P4), which recorded 28 °C.

The use of organic mulch also leads to changes in soil texture through the decomposition process. The application of *Trichoderma* can accelerate the decomposition of organic mulch within 1–2 months and protect the soil from direct impact of raindrops (Jumadi *et al*., 2021) [7]. Analytical results confirmed an increase in silt texture percentage. The control plot (P0) had a silt content of 34%, while P2 reached 65%, and P4 reached 80%.

Trichoderma was applied to the field prior to planting. However, soil biological laboratory tests conducted at 50 days after planting (DAP) showed that *Trichoderma* was undetectable. Several factors contributed to this result, including low organic carbon, soil temperature, humidity, and soil pH. According to (Sulistiyono, 2017) [17] *Trichoderma* thrives in neutral pH soil. The laboratory analysis indicated that the soil in the study site was alkaline. This alkalinity is attributed to the limestone-derived sediments prevalent in Madura and the low leaching of basic cations, which is a consequence of the dry climate and low rainfall in the region (Supriyadi, 2007) [18].

High soil pH levels are associated with a greater proportion of clay particles than silt and sand (Supriyadi, 2007) [18]. For optimal growth of shallot roots and bulbs, soils with crumb structure and clay to silt texture are ideal (Kurnianingsih *et al*., 2019) [8]. Based on productivity calculations, the highest yield was recorded in treatment plot P4, reaching 18.67 tons/ha, using 300 grams of *Trichoderma* combined with corn husk mulch.

To improve adoption among farmers, extension agents (PPL) should intensify their support and outreach so that farmers are more willing to utilize corn husk waste and bamboo leaf litter as organic mulch. This assistance can take the form of training sessions during regular meetings of farmer groups (poktan) or farmer group associations (gapoktan). The extension agents should deliver engaging and participatory educational material, facilitating two-way discussions with farmers.

For instance, a demonstration on the use of organic mulch can be conducted by bringing samples of corn husks and bamboo leaves, soaking them in water, draining, and placing them in containers. Once the materials are allowed to dry, they can be observed. The longer the mulch retains moisture before drying, the more effective it is considered as organic mulch.

4. Conclusion

The application of organic mulch from leaf litter (bamboo leaves and corn husks) and *Trichoderma* had a significant effect on soil texture, temperature, and pH levels. However, no significant effect was observed on soil permeability among the treatments. The highest productivity was achieved in treatment P4, which involved the use of 300 grams of *Trichoderma* combined with corn husk mulch, and exhibited a silty clay loam texture.

Farmers were generally unaware of the use of organic mulch from corn husks and bamboo leaves for shallot cultivation, and showed little interest in adopting it. Nevertheless, 15 out of 20 farmers were aware of the benefits of *Trichoderma* in plant cultivation, and all farmers expressed willingness to apply *Trichoderma* to their shallot crops.

5. References

1. Banjarnahor SM. Manfaat mulsa organik serasah daun bambu untuk menghambat pertumbuhan gulma pada tanaman bawang prei (*Allium porrum*). Skylandsea Profesional Jurnal Ekonomi, Bisnis dan Teknologi. 2022;2(2):178-182.
2. Badan Pusat Statistik. Rubaru dalam angka. Jakarta: Badan Pusat Statistik; 2021.
3. Eviati S. Analisis kimia tanah, tanaman, air dan pupuk. In: Proceedings of the National Academy of Sciences. Bogor: Balai Penelitian Tanah; 2009. p. 1-10. doi:10.1016/j.bpj.2015.06.056
4. Gulat AR, W. Keywords: Organic mulch, soil physical and chemical properties, palm oil. 2012. (Unpublished manuscript).
5. Herdiyantoro D. Upaya peningkatan kualitas tanah di Desa Sukamanah dan Desa Nanggerang Kecamatan Cigalontang Kabupaten Tasikmalaya Jawa Barat melalui sosialisasi pupuk hayati, pupuk organik dan olah tanah konservasi. Dharmakarya. 2015;4(2):47-53. doi:10.24198/dharmakarya.v4i2.10028
6. Iriany A, Santoso U, Farizal I, Hasanah F. Aplikasi beberapa komposisi mulsa organik lembar pada budidaya bawang merah (*Allium ascalonicum* L.). Jurnal Hortikultura Indonesia. 2022;50(2):180-185. Available from: https://eprints.umm.ac.id/98092/
7. Jumadi O, Junda M, Caronge MW, Syafruddin. *Trichoderma* dan pemanfaatan. Makassar: Penerbit Jurusan Biologi FMIPA UNM; 2021. Available from: http://eprints.unm.ac.id/21426/1/1.%20*Trichoderma*%20Dan%20Pemanfaatan_ISBN_Final.pdf
8. Kurnianingsih A, Susilawati, Sefrila M. Karakter pertumbuhan tanaman bawang merah pada berbagai komposisi media tanam. Jurnal Hortikultura Indonesia. 2019;9(3):167-173. doi:10.29244/jhi.9.3.167-173
9. Kusuma MDI. Pembuatan dan uji mulsa lembaran dari bahan baku limbah hasil pertanian. Jurnal Agroqua. 2019;17(2):115-125. doi:10.32663/ja.v17i2
10. Melsasail L, Warouw VRC, Kamagi YEB. Pengaruh penambahan lempung dan bahan organik serta dosis pupuk NPK terhadap pertumbuhan dan hasil bawang merah di media pasir pantai. Cocos. 2019;2(6):1-14.
11. Muliana M, Iswahyudi I, Juanda BR. Pengaruh dosis *Trichoderma* harzianum dan varietas bawang merah mengendalikan penyakit moler (*Fusarium oxysporum*) dan produksi tanaman bawang merah (*Allium ascalonicum* L.). Jurnal Ilmu Pertanian Tirtayasa. 2024;6(2):377-391. doi:10.33512/jipt.v6i2.28831
12. Putrayanto AR. Aplikasi mulsa organik pada lahan salak: Pengaruh peningkatan bahan organik tanah terhadap porositas dan infiltrasi. 2017. (Unpublished manuscript).
13. Putri YD, Sirajang N, Sunusi N. Analisis kovariansi rancangan petak terbagi pada rancangan acak kelompok (RAK) dengan data hilang. Jurnal Matematika Statistika dan Komputasi. 2018;14(2):114-120. doi:10.20956/jmsk.v14i2.3549
14. Rusdiana RY, Fariroh I. Penerapan ANOVA dengan respon data count pada kasus perkecambahan serbuk sari

jagung. Jago Tolis: Jurnal Agrokompleks Tolis. 2024;5(1):51-58. doi:10.56630/jago.v5i1.712

15. Suharyatun S, Telaumbanua M, Haryanto A, Wisnu FK. Empirical model for estimation of soil permeability based on soil texture and porosity. Journal of Agricultural Engineering. 2023;12(3):533-544.
16. Sukmawan Y, Sesar AKR, Parapasan Y, Riniarti D, Utoyo B. Pengaruh mulsa organik dan volume air siraman pada beberapa sifat kimia tanah di pembibitan utama kelapa sawit. In: Prosiding Seminar Nasional Pengembangan Teknologi Pertanian. Lampung: Politeknik Negeri Lampung; 2018. p. 273-279. Available from: http://jurnal.polinela.ac.id/index.php/Prosiding
17. Sulistiyono FD. Karakteristik fisiologi empat antagonis isolat *Trichoderma* sp. sebagai agensi hayati. Sains Natural: Journal of Biology and Chemistry. 2017;5(1):24-29. doi:10.31938/jsn.v5i1.96
18. Supriyadi S. Kesuburan tanah di lahan kering Madura. Embryo. 2007;4(2):124-131.