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Effect of Soil Amendment Application on Productivity of Watermelon (Citrullus vulgaris Schard.) in Suboptimal Land

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ABSTRACT

Inappropriate land management system has emerged as a serious issue in agricultural development. Instead of boosting land productivity, suboptimal land use has become a viable option for regional agricultural development. However, this has not resulted in considerable increases in agricultural productivity. The purpose of this study was to improve soil parameters and increase watermelon (*Citrullus vulgaris* Schard) production by applying soil amendments to suboptimal land. This study was conducted utilizing a factorial randomized group design with two factors. The first factor was the application of mulch (M) with three treatment levels: M0 = no mulch, M1 = reed mulch, and M2 = coconut leaf mulch; the second factor was the application of bird manure fertilizer (P) with three treatment levels: P0 = no fertilizer, P1 = 10 t/ha fertilizer, and P2 = 20 t/ha. The data was analyzed using ANOVA and Duncan's multiple range test (significant at *P* < 0.05). The study was conducted at Khairun University's Campus IV in Madihutu Village, Kao Teluk District, North Halmahera Regency. Soil parameters and plant agronomic traits were among the observed variables. The findings revealed that the mulch and bird manure treatments had no significant impact on soil characteristics. In terms of plant agronomic features, the mulch-free treatment had the greatest impact on watermelon plant growth and yield, whereas the 10 t/ha fertilizer treatment outperformed the other treatments.

Keywords: bird manure fertilizer, mulch, suboptimal land, watermelon plant

INTRODUCTION

Suboptimal land is defined as areas with inherently low production due to reasons such as poor soil qualities, a harsh environment, or scattered urbanization. In agricultural settings, such land frequently exhibits low fertility, poor water retention, and restricted biological activity, limiting crop production unless managed with focused treatments such as enhanced fertilization, organic amendments, or direct nutrient feeding techniques. Inappropriate land management is a serious issue nowadays since it causes land degradation. According to Aji *et al.* (2020), land degradation was characterized by the inability of the land to give nutrients to plants. As a result, soil fertility decreases, posing a significant barrier to sustainable land management (Tobi *et al.* 2013, Hartati *et al.* 2023). On the other hand, land degradation has the effect of transforming land into suboptimal land. Suboptimal land is currently being exploited for agricultural purposes in both dry and swampy areas. Sustainable land management solutions are required to decrease land degradation and boost agricultural output (Abdollahi & Munkholm 2014, Ospanbayev *et al.* 2023). Applying mulch and fertilizer could help minimize land degradation and increase soil quality (Rossi *et al.* 2024). Mulch and manure are extremely effective at improving soil quality and productivity in suboptimal or degraded areas. Long-term use of organic manure and straw mulching reduces soil erosion, runoff, and nutrient loss while increasing soil nutrient content, water-stable aggregates, and microbial diversity, all of which improve soil multifunctionality and ecosystem resilience, particularly when combined (Shi *et al.* 2025).

Mulching in agricultural techniques is thought to reduce evaporation, improve the qualities of the top layer of soil, and improve the condition of young soil (Helda 2010). Mulching has been proposed as an efficient approach for managing temperature and soil moisture conditions, lowering soil evaporation (Li *et al.* 2013), limiting weed growth (Nwosisi *et al.* 2019), and enhancing crop yields (Qin *et al.* 2015). One type of mulch is organic mulch made from straw. Straw mulch is generally acknowledged for its ability to improve soil health, conserve water, and increase crop yields (Visconti *et al.* 2024). Straw mulch improves soil organic carbon, raises soil microbial activity (Liu *et al.* 2023), regulates soil temperature, and promotes root growth, all of which lead to improved soil structure and fertility (Du *et al.* 2022).

Furthermore, fertilization can increase nutrient availability by delivering nutrients to plants both directly and indirectly. Fertilization, on the other hand, has the

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potential to stimulate plant growth and development. Organic fertilizer as a soil amendment can increase soil fertility (Rofita *et al.* 2021). Manure is a sort of organic fertilizer used in agricultural techniques that is both ecologically beneficial and reasonably priced for farmers. Organic fertilizer plays a vital role in a sustainable agricultural system and can be used instead of chemical fertilizers to successfully boost soil fertility (Soobhany 2019, Xiang *et al.* 2022, Zhang *et al.* 2023). According to He *et al.* (2023) and Scotti *et al.* (2015), organic fertilizer plays an important function in enhancing crop yields and soil quality. Furthermore, manure provides slow-release nutrients to plants, making it environmentally benign. Furthermore, organic fertilizers have been shown to boost soil biota activity and diversity (Minardi *et al.* 2020). Several earlier research found that spreading manure had a greater effect on plant productivity than using chemical fertilizers (McAndrews *et al.* 2006).

Watermelon (Citrullus vulgaris Schard.) is an annual horticultural crop with significant commercial significance (Annisa 2017). Watermelon growing in Indonesia boosts rural incomes, provides chances for technological improvement, and has a big impact on the country's horticultural landscape. Apart from that, watermelons have a pleasant taste and a high-water content. According to Manengkey *et al.* (2022), a watermelon contains 91% water, 6% sugar, and numerous vitamins including A, B1, B6, and C. According to Daniel (2016), watermelon includes citrulline and carotenoids, which contain lycopene, an antioxidant that protects against free radicals. Watermelon also contains flavonoid antioxidants such lycopene, beta carotene, lutein, zeaxanthin, and cryptoxanthin, which help to prevent cancers of the colon, prostate, breast, endometrial, lung, cervix, and pancreas (Sibuea *et al.* 2022). Watermelon cultivation in Indonesia is a profitable and developing agricultural business, with major production hubs in Riau, Lampung, Central Kalimantan, East Java, and Southeast Sulawesi. According to studies, watermelon cultivation is economically viable, with high yields (for example, 15,509 kg/ha/season in Riau) and favorable return-cost ratios that frequently surpass 2.5, indicating good profitability and efficiency for farmers (Napitupulu & Paman 2025). Wahyudi *et al.* (2023) revealed that breeding initiatives in Lampung have resulted in hybrid types with better yield, sweetness, and nutritional content, which has boosted productivity and market appeal.

Mulch and swallow bird manure fertilizer can be used to grow watermelon on suboptimal ground, resulting in high and sustained plant growth and productivity. Aside from that, this treatment was believed to help improve soil fertility and promote optimal plant development and output. Fertilizer made from bird feces, notably that of poultry, contains organic carbon, nitrogen, phosphate, potassium, and critical micronutrients, which improves soil fertility and biological activity, including increased microbial diversity and enzymatic activity (Kobierski *et al.* 2017). Poultry manure improves pH, organic matter, and nutrient availability in tropical and degraded soils, promoting soil recovery and plant development, with the best outcomes frequently achieved at moderate to high application rates (e.g., 6−10 t/ha) (Cairo *et al.* 2023).

The purpose of this study was to boost the production of watermelon by applying mulch and bird manure fertilizer to suboptimal land.

METHODS

Study Site and Experimental Design

The study was conducted from April to November 2023 and was separated into two parts: field research and laboratory analysis. Field study was done at 0°52′17.83″N and 127°39′3.60″E, administratively located at Campus IV Khairun University, Bangko Hamlet, Bobaneigo Madihutu Village, Kao Teluk District, North Halmahera Regency, North Maluku Province, Indonesia (Figure 1). Laboratory analysis was performed at the Khairun University Faculty of Agriculture's Soil Science Laboratory.

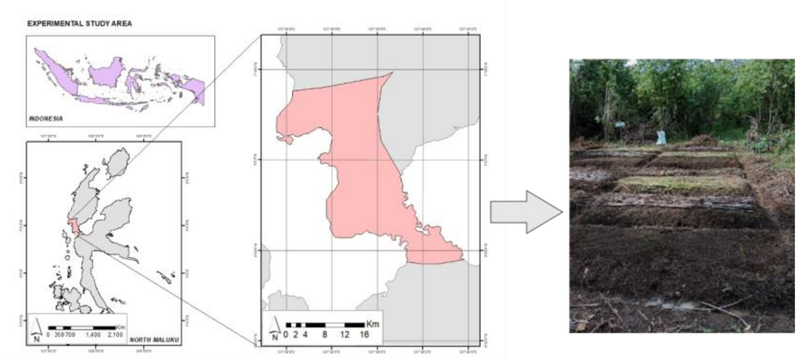
The materials employed in this study included INKAI F1 Non-seed Yellow watermelon seeds, swallow bird feces, reed mulch, and coconut leaves. Meanwhile, this research used hoes, buckets, rope, measuring tape, hand sprayer, calculator, scales, research plot boards, research title boards, sample stakes, bags, bamboo, machetes, and other study-related materials and equipment.

Research Design

The study followed a factorial randomized block design (RBD) with two components, mulch (M) and fertilizer (P), each with three treatment levels (Table 1). The total number of treatment combinations was nine, each with two replications, yielding 18 experimental units.

Soil Sampling, Growth Measurement, and Statistical Analysis

The first step in conducting research was to collect soil samples. The samples were collected at the rhizosphere zone (0−30 cm). Then, a preliminary study was performed to determine the initial soil content before treatment. The observed variables in soil analysis included physicochemical properties: soil texture, moisture, bulk density (BD), particle density (PD), soil porosity, permeability, soil total nitrogen, soil organic carbon (SOC), C/N ratio, P availability, exchangeable bases (Ca, Mg, K, Na), and cation exchange capacity (CEC). Soil characteristics were analyzed using normal laboratory procedures (Van Reeuwijk 2002). Plant agronomic (growth and yield)



a b

Figure 1 a: Administration map of experimental study area and b: field experimental area. in Bobaneigo Madihutu Village, Kao Teluk District, North Halmahera Regency, North Maluku Province, Indonesia

Table 1 Treatment combinations

Code	Treatment composition
M0P0	No mulch + No bird manure
M0P1	No mulch + 10 t/ha bird manure
M0P2	No mulch + 20 t/ha bird manure
M1P0	Reed mulch + No bird manure
M1P1	Reed mulch + 10 t/ha bird manure
M1P2	Reed mulch + 20 t/ha bird manure
M2P0	Coconut leaf mulch + No bird manure
M2P1	Coconut leaf mulch + 10 t/ha bird manure
M2P2	Coconut leaf mulch + 20 t/ha bird manure

characteristics included plant length, number of leaves, fruit weight, and fruit diameter. During the growing season, parameter measurements such as plant length and number of leaves were taken once a month, while fruit weight and diameter are measured after harvest. The development and production of plants were analyzed using ANOVA and Duncan's multiple range test (significant at $p < 0.05$). The correlation between variables was examined at $\alpha = 5\%$ using Minitab software Version 18.

Based on the pre-treatment investigation, the soil's physical and chemical qualities remained unsatisfactory (Table 2). The soil was classed as silty loam with modest concentrations of various chemical characteristics.

RESULTS AND DISCUSSION

Soil Classification

Soil orders in the research region were classified as Ultisols, with subgroups classified as Typic Hapludults under the USDA classification system (Soil Survey Staff 2022). This type of soil has acidic pH (5−5.5), poor base saturation, and chlorine deposition in the subsoil. The epipedon was ochric or umbric, but the endopedon was typically argillic or kandic (Fiantis 2016). Ultisols are distinguished by high clay content in the subsurface, which can impede root development (Curi *et al.* 2022).

The Effects of Mulch and Bird Manure Application on Soil Properties

The application of mulch and bird manure, as well as their interaction, had no significant effect on the soil's physicochemical properties; however, as shown by the means value, the treatments offered different means values for the soil's physicochemical properties (Figure 2). The combination of mulch and bird manure reduced soil bulk density, as demonstrated in treatments M0P1, M0P2, M1P1, and M1P2. Bird excrement is 50.46% organic (Talino 2013). The high concentration of organic carbon in manure can enhance the soil's structure, loosening it and lowering its unit weight value. According to Barzegar *et al.* (2002), organic matter from manure contributed significantly to the bulk density of the soil in the till layer. The combination of mulch and bird manure had no significant influence on soil parameters, with the M1P0 treatment yielding the greatest value. The mixture of mulch and bird manure significantly increased soil porosity (Figure 3). The addition of organic matter to the soil via fertilizer creates positive space, increasing total pore space and improving the aggregation system in the soil body (Surya *et al.* 2017). Bird excrement has been proven in studies to promote soil biological activity and water penetration (Adeyemo *et al.* 2019). It

Table 2 Soil analysis before treatment in Bobaneigo Madihutu Village, Kao Teluk District, North Halmahera Regency, North Maluku Province, Indonesia

Soil property	Value	Category
Soil texture (%):		
Sand (%)	10	Silty loam
Silt (%)	65	
Clay (%)	25	
Soil moisture content (%)	30.3	–
Bulk density (g/cm^3)	1.17	–
Particle density (g/cm^3)	1.57	–
Soil porosity (%)	25.48	–
Soil permeability (cm/h)	0.70	–
Total nitrogen (%)	0.18	Low
Available-P (ppm)	10.54	Moderate
Soil organic carbon (%)	1.53	Low
C/N ratio	9	–
Ca (cmol$^{(+)}$/kg)	5.18	Low
Mg (cmol$^{(+)}$/kg)	0.27	Very low
K (cmol$^{(+)}$/kg)	0.16	Low
Na (cmol$^{(+)}$/kg)	0.22	Low
CEC (cmol$^{(+)}$/kg)	18.75	Moderate
Base saturation (%)	31	Low

Source: Soil Science Laboratory, Faculty of Agriculture, Universitas Khairun (2023). The assessment criteria were based on the Soil Research Institute (2009).

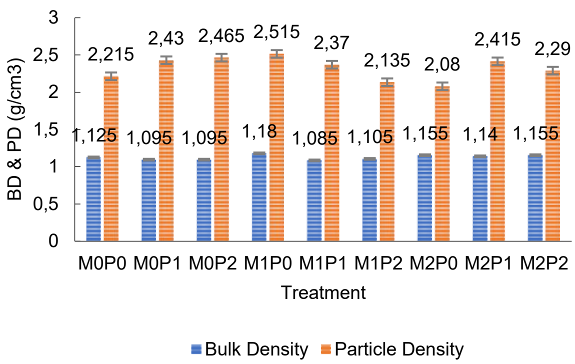


Figure 2 Effects of mulch and bird manure on bulk density and particle density.

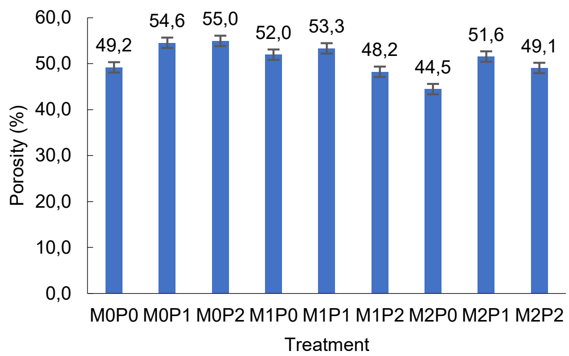


Figure 3 Effects of mulch and bird manure on soil porosity.

also improves crop yield and quality, including vegetative growth and seed productivity (Gavrilets *et al.* 2022, Hoover *et al.* 2019, Rasool *et al.* 2023).

Mulch and bird manure were able to raise pH in M0P1 and M1P0 treatments (Figure 4). This is because organic fertilizer has entirely decomposed, making the nutrients provided to the soil available and capable of increasing humus colloids (Brar *et al.* 2015. Neina 2019). In contrast, the pH of bird feces was 7.97 (Talino 2013). Bird manure fertilizer contributes to an increase in soil pH. In the M1P1 experiment, using mulch and bird excrement resulted in a considerable increase in soil moisture (Figure 5). Mulch is beneficial because it can help to store soil moisture. The same thing happens when applying straw mulch. Gebeyhu and Markos (2023) discovered that straw mulch might retain 5−10% water after being put to the soil. In addition to providing nutrients to the soil, organic fertilizer can effectively bind water, enhance the soil's aeration system, and stimulating the activity of organisms involved in the humification and decomposition processes.

The Effects of Mulch Application

Mulching had a substantial effect on plant length and leaf number, but not on yield. The first and fourth observations showed a significant effect of mulch application, whereas the second and third did not. The first and second observations revealed no significant effect, but the third and fourth observations did. Mulch application in the M1 and M2 treatments did not differ substantially from one another but did differ considerably from the M0 treatment (Table 3). In the first observation, the M0 treatment produced the lowest value for plant length when compared to the other treatments. However, in the subsequent observations, the M0 treatment produced the highest value for the length of the watermelon plant. This condition

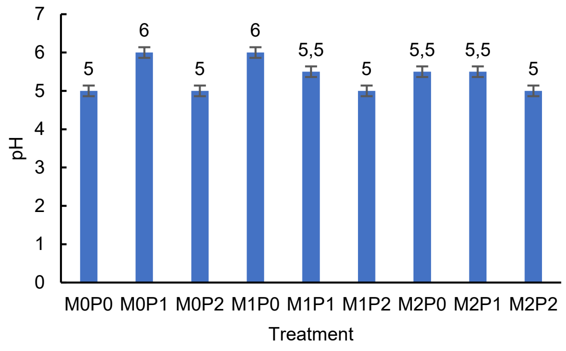


Figure 4 Effects of mulch and bird manure on soil pH.

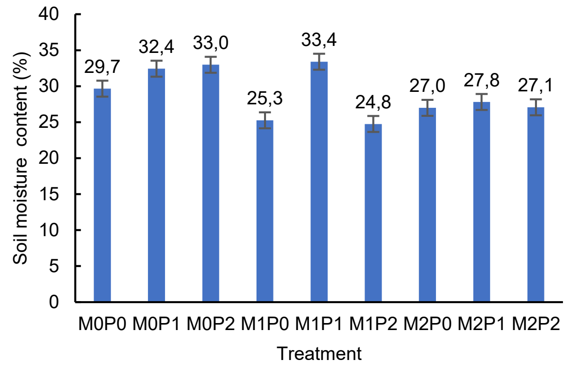


Figure 5 Effects of mulch and bird manure on soil moisture content.

Table 3 Effects of mulch application on plant length

Treatment	Plant length in the ith observation			
	1	2	3	4
MO	6.17[b]	18.50	47.33	129.67[a]
M1	10.50[a]	17.83	23.00	62.17[b]
M2	9.08[a]	16.67	33.17	63.17[b]
$LSD_{0.05}$	2.09	–	–	58.54

Remark: Means followed by the same letters are not significantly different based on the LSD test at 0.05.

demonstrates that mulch application can hinder the growth of plant length, as evidenced by the treatment without mulch, which resulted in longer plant length than reed mulch (M1) or coconut leaf mulch (M2). Because the mulch was formed from annual plants, its sluggish rate of decomposition impedes the process of nutrient delivery to the treated layer. According to the USDA (2019), grass contains more organic matter than forest plants since its life cycle is often shorter.

The effects of mulching became obvious in the third and fourth observations (Table 4). Like the plant length variable, the M0 treatment produced the maximum number of leaves compared to the other two treatments (M1 and M2). Mulching had no significant effect on yield parameters; however, each treatment had different results for each yield parameter. Figures 6 and 7 illustrate the impacts of mulching. The M0 treatment had the greatest value for yield characteristics. This circumstance demonstrates that mulching is ineffective in promoting the growth and productivity of watermelon plants, as watermelon is a crop commodity that requires an open growing medium with no soil cover.

The Effects of Bird Manure Application

The treatment of bird manure had a considerable influence on plant length (Table 5). In the first and second observations, each treatment produced significantly different pant length values, and the second and third observations revealed that the treatment without mulching was the best. Meanwhile, in the third and fourth observations, the P0 treatment had a significantly different effect than the other two treatments, but the P1 and P2 treatments did not differ significantly. Plant length was highest in P1 treatment, and lowest in P0 treatment. This circumstance indicates that the watermelon plant's length decreases with both insufficient and excessive fertilizer application.

The use of bird manure had no significant influence on the quantity of leaves in the first observation. However, substantial effects were found in the second, third, and fourth observations (Table 4). P0 treatment produced considerably different effects than P1 and P2 treatments, although P1 and P2 treatments were not statistically different. The P0 treatment had the fewest leaves, while the P1 treatment had the most. The treatment of bird manure had no significant effect on the yield metrics of watermelon plants. However, each treatment produced different results for each yield parameter (Figures 8 and 9).

The effect of bird manure application was clearly visible in the P1 treatment (10 t/ha of manure), while the P0 treatment (no manure) yielded the lowest value (Figures 8 and 9). However, the addition of subsequent doses reduced plant yields. The P1 treatment enhances plant growth and yields. This situation indicates that watermelon plants' nutrient requirements have been met, implying that the available nutrients are sufficient to maintain plant development and yield. Thus, administering a higher dose tends to diminish plant growth and yield. Bird manure is vital for plant photosynthesis because it boosts the soil's ability to hold water, allowing soil moisture in the cultivated layer to become available while also maintaining the rate of soil decomposition by microorganisms. Putra and Cahyono (2022) also indicated that bird excrement

Table 4. Effect of mulch application on number of watermelon leaves

Treatment	Number of leaves in the ith observation			
	1	2	3	4
MO	2	6	10^{a}	30^{a}
M1	1	4	5^{b}	14^{ab}
M2	2	5	7^{ab}	13^{b}
LSD$_{0.05}$	–	–	4.11	16.71

Remark: Means followed by the same letters are not significantly different based on the LSD test at 0.05.

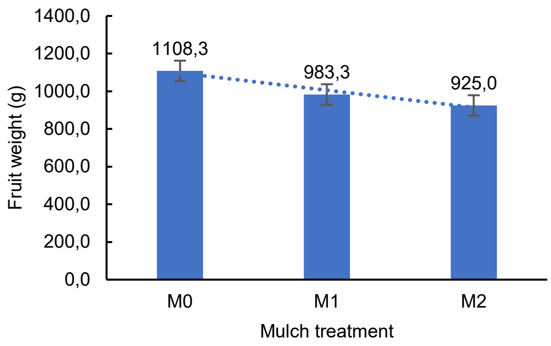


Figure 6 Effects of mulch application on watermelon weight.

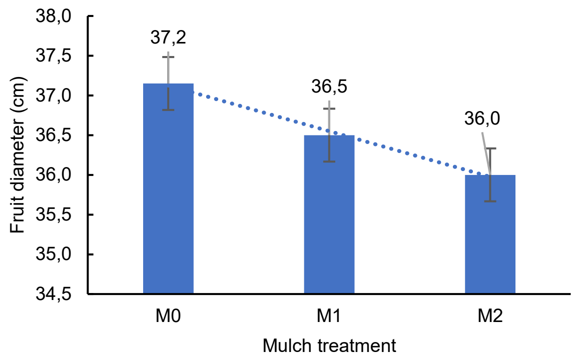


Figure 7 Effects of mulch application on watermelon diameter.

Table 5 Effects of bird manure application on plant length

Treatment	Plant length in the ith observation			
	1	2	3	4
P0	7.17b	10.50b	15.67b	23.17b
P1	9.00ab	19.83ab	46.17a	119.67a
P2	9.58a	22.67a	41.67a	112.17a
LSD 0.05	2.09	12.03	24.42	58.54

Remark: Means followed by the same letters are not significantly different based on the LSD test at 0.05.

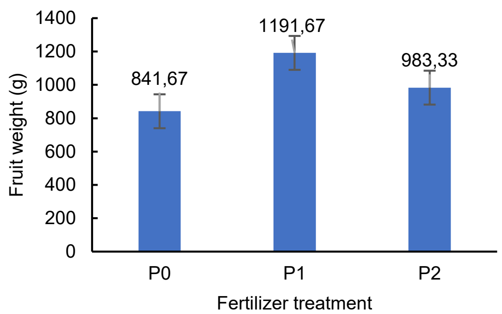


Figure 8 Effects of bird manure application on watermelon weight.

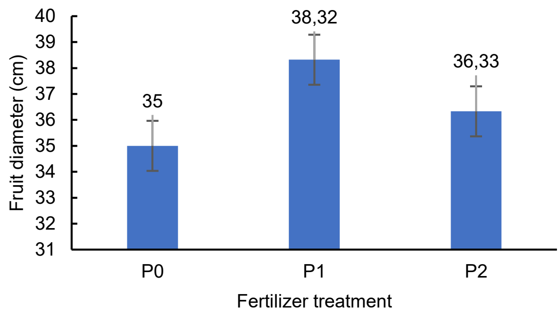


Figure 9 Effects of bird manure application on watermelon diameter.

contains 0.13% potassium (K). This means that applying bird manure helps to produce ATP while also promoting plant physiological processes such as photosynthesis, carbohydrate accumulation, translocation, transportation, stomatal opening and closing, and regulating the distribution of water, oxygen (O2), and carbon dioxide (CO2) absorbed in tissues and cells (Rawat *et al.* 2022). Plant growth is commonly characterized as a rise in the size, weight, and quantity of plant cells. Darmawan and Justika (2010) described plant growth as a rise in plant size followed by an increase in dry weight. Cell division is the first stage of plant growth, followed by cell expansion and differentiation. Growth happens only in specific areas, notably in meristem tissues. Plants generate a variety of organs as they grow and mature. Plant organs are often divided into vegetative and generative organs. Vegetative organs are roots, stems, and leaves, whereas generative organs comprise flowers, fruit, and seeds.

CONCLUSION

In the final observation, mulching had a substantial impact on plant development. However, no substantial influence was observed on the yield metrics. Similarly, the application of bird manure had a substantial effect on plant development but did not yield characteristics. P1 treatment (10 t/ha of bird manure) produced the best results. Integrated management is required to boost plant productivity on suboptimal land. For optimal and long-term outcomes, soil amendment kinds and doses should be selected based on soil characteristics, prices, and environmental safety.

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REFERENCES

Abdollahi L, Munkholm LJ. 2014. Tillage system and cover crop effect on soil quality: Chemical, mechanical, and biological properties. *Soil Science of America Journal.* 78(1): 262–270. https://doi.org/10.2136/sssaj2013.07.0301

Adeyemo A, Akingbola O, Ojeniyi S. 2019. Effects of poultry manure on soil infiltration, organic matter contents and maize performance on two contrasting degraded Alfisols in southwestern Nigeria. *International Journal of Recycling of Organic Waste in Agriculture*. 8(1): 73-80. https://doi.org/10.1007/s40093-019-0273-7

Aji K, Maas A, Nurudin M. 2020. Relationship between soil morphology and variability of upland degradation in Bogowonto Watershed, Central Java, Indonesia. *Journal of Degraded and Mining Lands Management*. 7(3): 2209–2219. https://doi.org/10.15243/jdmlm.2020.073.2209

Annisa G. 2017. Respon pertumbuhan dan produksi tanaman melon (*Cucumis melo* L.) terhadap pemberian pupuk organik cair *Tithonia diversifolia*. *Prosiding Seminar Nasional 2017 Fak. Pertanian UMJ*. 8: 104–114.

Amir B, Abdillah A. 2019. Respon Pertumbuhan dan Hasil Tanaman Melon (*Cucumis melo* L.) melalui pemberian POC kotoran sapi dan mulsa plastik. *Jurnal Pertanian Berkelanjutan*. 7(3): 234–241. https://doi.org/10.30605/perbal.v7i3.1420

Aristoteles, Miswar D, Bernando SDAH, Prayoga A, Wulandari NA, Yasami IE, Prambudiningtyas DM, Laksono KA, Hutauruk GA. 2021. Pembuatan pupuk kompos dari limbah organik rumah tangga di Desa Gedung Harapan, Kecamatan Jati Agung, Lampung Selatan. *Jurnal Pengabdian Kepada Masyarakat (Buguh).* 1(1):17–24. https://doi.org/10.23960/buguh.v1n1.64

Barzegar AR, Yousefi A, Daryashenas A. 2002. The effect of addition of different amounts and types of organic materials on soil physical properties and yield of wheat. *Plant and Soil.* 247: 295–301. https://doi.org/10.1023/A:1021561628045

Basuki JA, Yunus, Purwanto, E. 2009. Peranan mulsa dalam meningkatkan pertumbuhan dan produksi cabai melalui modifikasi kondisi fisik di dalam tanah. *Jurnal Partner*. 16(2): 73–77.

Brar BS, Singh J., Singh G, Kaur G. 2015. Effects of longterm application of inorganic and organic fertilizers on soil organic carbon and physical properties in maize wheat rotation. *Agronomy*. 5(2):220–238. https://doi.org/10.3390/agronomy5020220

Cairo CP, Diaz MB, Machado DAJ, Rodríguez LO. 2023. Effects of poultry manure on structure and some indicators of fertility in tropical soils. *Archives of Agronomy and Soil Science*. 69: 2692–2702. https://doi.org/10.1080/03650340.2023.2171020

Curi N, Silva SHG, Inda AV. 2022. Humid subtropical ecozone with emphasis on Acrisols and Alisols. *Earth Systems and Environmental Sciences Elsevier*. 4: 343-352. https://doi.org/10.1016/B978-0-12-822974-3.00068-9

Darmawan J, Justika SB. 2010. *Dasar-Dasar Fisiologi Tanaman*. Jakarta (ID): SITC.

Du C, Li L, Effah Z. 2022. Effects of straw mulching and reduced tillage on crop production and environment: A review. *Water*. 14(16): 2471. https://doi.org/10.3390/w14162471

Fiantis, D. 2016. *Morfologi dan Klasifikasi Tanah*. Lembaga Pengembangan Teknologi Informasi dan Komunikasi (LPTIK). Padang (ID): Universitas Andalas. https://doi.org/10.25077/car.4.2

Gebeyhu B, Markos G. 2023. Assessment of soil mulching field management, and deficit irrigation effect on productivity of watermelon varieties, and aqua crop model validation. *Heliyon*. 9(11): 2405–8440. https://doi.org/10.1016/j.heliyon.2023.e21632

Gavrilets T, Danilov V, Matenkova E, Petrov A, Sadokhina T, Kokorin A, Sadokhin, A. 2022. Soybean response to organic fertilizer based on bird manure. *Bulletin of NSAU (Novosibirsk State*

Agrarian University). 3: 17–25. https://doi.org/10.31677/2072-6724-2022-64-3-17-25

Hartati TM, Dwiputranti O. 2021. Pemberdayaan kelompok ekonomi produktif melalui pelatihan pembuatan pupuk organik dari kulit pisang. *Jurnal Pengabdian Kepada Masyarakat Undana*. 15(2): 6–12. https://doi.org/10.35508/jpkmlppm.v15i2.5646

Hartati TM, Sunarminto BH, Utami SHN, Purwanto BH, Nurudin M, Aji K. 2023. Distribution of soil morphology and physicochemical properties to assess the evaluation of soil fertility status using soil fertility capability classification in North Galela, Indonesia. *Journal of Degraded and Mining Lands Management*. 10(3):4405–4415. https://doi.org/10.15243/jdmlm.2023.103.4405

He Z, Ding B, Pei S, Cao H, Liang J, Li Z. 2023. The Impact of Organic Fertilizer Replacement on Greenhouse Gas Emissions and Its Influencing Factors. *Science of The Total Environment*. 905(166917). ISSN 0048–9697. https://doi.org/10.1016/j.scitotenv.2023.166917

Hoover N, Law J, Long, L, Kanwar R, Soupir M. 2019. Long–term impact of poultry manure on crop yield, soil and water quality, and crop revenue. *Journal of Environmental Management*. 252: 109582. https://doi.org/10.1016/j.jenvman.2019.109582

Kobierski M, Bartkowiak A, Lemanowicz J, Piekarczyk M. 2017. Impact of poultry manure fertilization on chemical and biochemical properties of soils. *Plant Soil and Environment*. 63: 558–563. https://doi.org/10.17221/668/2017-PSE

Li R, Hou X, Jia Z, Han Q, Ren X, Yang, B. 2013. Effects on soil temperature, moisture, and maize yield of cultivation with ridge and furrow mulching in the rainfed area of the loess plateau, China, Agric. *Water Management*. 116: 101–109. https://doi.org/10.1016/j.agwat.2012.10.001

Liu B, Dai Y, Cheng X, He X, Bei Q, Wang Y, Zhou Y, Zhu B, Zhang K, Tian X, Duan M, Xie X, Wang L. 2023. Straw mulch improves soil carbon and nitrogen cycle by mediating microbial community structure and function in the maize field. *Frontiers in Microbiology*. 14. https://doi.org/10.3389/fmicb.2023.1217966

Neina, D. 2019. The role of soil pH in plant nutrition and soil remediation. *Applied and Environ-mental Soil Science*. 3: 1–10. https://doi.org/10.1155/2019/5794869

Nursakina N, Ramli R, Bahrudin B. 2020. Respon Pertumbuhan dan Hasil Tanaman Semangka *(Citrullus vulgaris,* Schard) Terhadap Pemberian Pupuk NPK dan Mulsa Organik. *e–J. Agrotekbis.* 8 (2): 361–368. https://doi.org/10.33059/jupas.v8i2.4406

Nwosisi S, Nandwani D, Hui D. 2019. Mulch treatment effect on weed biomass and yields of organic Sweet potato cultivars. *Agronomy*. 9:190. https://doi.org/10.3390/agronomy9040190

Manengkey LY, Najoan J, Pamandungan Y. 2022. The effect of using several types of mulch on the growth and production of watermelon plants (Citrullus Vulgaris). *Jurnal Agroekoteknologi Terapan (Applied Agroecotechnology Journal)*. 3(1): 2797–0647. https://doi.org/10.35791/jat.v3i2.44104

McAndrews GM, Liebman M, Cambardella CA, Richard TL. 2006. Residual effects of composted and fresh solid swine (Sus scrofa L.) manure on soybean [Glycine max (L.) Merr.] growth and yield. *Agronomy Journal*. 98(4): 873–882. https://doi.org/10.2134/agronj2004.0078

Minardi S, Haniati IL, Nastiti AHL. 2020. Adding manure and zeolite to improve soil chemical properties and increase soybean yield. Sains Tanah *Journal of Soil Science and Agroclimatology*. 17(1): 1–6. https://doi.org/10.20961/stjssa.v17i1.41087

Napitupulu C, Paman U. 2025. Analisis Ekonomi Usahatani Semangka Di Kecamatan Binawidya Kota Pekanbaru Provinsi Riau. *Dinamika Pertanian*. 40(3): 19927. https://doi.org/10.25299/dp.2024.vol40(3).19927

Oktarina H. 2015. Respon pertumbuhan dan hasil tanaman melon terhadap dosis pupuk Phonska. *Agritrop Jurnal Ilmu–Ilmu Pertanian*.13(2): 171–180.

Ospanbayev ZA, Doszhanova Y, Abdrazakov R, Zhapayev A, Sembayeva A, Zakieva A, Yertayeva Z. 2023. Tillage system and cover crop effects on organic carbon and available nutrient contents in light chestnut soil. *Eurasian Journal of Soil Science*. 12(3): 238–243. https://doi.org/10.18393/ejss.1268176

Putra AB, Cahyono E. 2022. Does swallow droppings and npk fertilizer have a good impact on onion growth and results on peat? *Agaricus: Advances Agriculture Science & Farming*. 2(1): 7–13. https://doi.org/10.32764/agaricus.v2i1.2769

Qin W, Hu C, Oenema O. 2015. Soil mulching significantly enhances yields and water and nitrogen use efficiencies of maize and wheat: A meta-analysis. *Science Reports*. 5: 16210. https://doi.org/10.1038/srep16210

Rawat J, Pandey N, Saxena J. 2022. *Role of Potassium in Plant Photosynthesis, Transport, Growth and Yield*. In: Iqbal N, Umar S. (eds) Role of Potassium in Abiotic Stress. Singapore (SG): Springer. https://doi.org/10.1007/978-981-16-4461-0_1

Rofita, Utami SNH, Maas A, Nurudin M. 2022. Effects of manure and chemical fertilizers on maize performance in the steep hillside with and without terraces in North Halmahera, Indonesia. *Ilmu Pertanian (Agricultural Science)*. 7(1): 56–67. https://doi.org/10.22146/ipas.68139

Rossi G, Beni C, Neri U. 2024. Organic mulching: A sustainable technique to improve soil quality. *Sustainability*. 16(23). 10261 https://doi.org/10.3390/su162310261

Scotti RG, Bonanomi R, Scelza A, Zoina MA, Rao. 2015. Organic amendments as a sustainable tool to recover fertility in intensive agricultural systems. *Journal of Science and Plant Nutrition*. 5 (2): 333–352. https://doi.org/10.4067/S0718-95162015005000031

Sibuea SJ, Chotimah HENC, Kresnatita S, Oemar O, Sajarwan A. 2022. Respon Pertumbuhan dan Hasil Tanaman Semangka *(Citrullus vulgaris* Schard*)* Akibat Pemberian POC Limbah Buah–buahan di Tanah Gambut. *Jurnal Agri Peat*. 23(2): 102–110. https://doi.org/10.36873/agp.v23i2.5970

Shi Y, Li T, Zheng L, Jing X, Hussain H, Zhang Q. 2025. Enhancing soil multifunctionality through restoring erosion environment and microbial functions combined with organic manure and straw mulching. *Agriculture, Ecosystems & Environment*. 383: 109515. https://doi.org/10.1016/j.agee.2025.109515

Soil Survey Staff. 2022. *Keys Soil Taxonomy,* 13th Ed. Washington (US): USDA. https://doi.org/10.1016/j.jclepro.2019.118413

Soobhany N. 2019. Insight into the recovery of nutrients from organic solid waste through biochemical conversion processes for fertilizer production: a review. *J Clean Prod*. 241: 118413.

Surya JA, Nuraini Y, Widianto. 2017. Kajian porositas tanah pada pemberian beberapa jenis bahan organik di perkebunan kopi robusta. *Jurnal Tanah dan Sumberdaya Lahan*. 4(1): 463–471.

Susiawan YS, Rianto H, Susilowati YE. 2018. Pengaruh pemberian mulsa organik dan saat pemberian pupuk NPK 15:15:15 terhadap hasil tanaman baby buncis (*Phaseolus vulgaris,* L.) varietas Perancis. *Jurnal Ilmu Pertanian Tropika dan Subtropika.* 3(1): 22–24.

Talino H. 2013. *Effect Of Applying Several Doses of Swallow Manure Fertilizer on The Growth and Yield of Mung Bean Plants in Ultisols.* [Master's thesis]. Pontianak (ID): Universitas Tanjungpura

Tobi FO, Ngobesing ESC, Yinda GS, Boukong A, Omoko M, Bitondo D, Mvondo ZAD. 2013. Soil fertility capability classification (FCC) for rice production in Cameroon lowlands. *African Journal of Agricultural Research.* 8(119):1650–1660. https://doi.org/10.5897/AJAR12.1576

USDA. 2019. *Soil Organic Matter: Soil Quality Kit*. Guides for Educators. Washington (US): USDA.

Van Reeuwijk LP. 2002. *Procedures for Soil Analysis*. Den Haag (NL): International Soil Reference and Information Centre.

Visconti F, Peiró E, Pesce S, Balugani E, Baixauli, C., De Paz, J. 2024. Straw mulching increases soil health in the inter-row of citrus orchards from Mediterranean flat lands. *European Journal of Agronomy*.155: 127115. https://doi.org/10.1016/j.eja.2024.127115

Wahid W, Tando E, Murni WS. 2020. Optimalisasi pengelolaan lahan suboptimal melalui aplikasi teknologi pertanian dalam mendukung ketersediaan dan ketahanan pangan. In: *Prosiding Seminar Nasional Lahan Suboptimal ke-8 Tahun 2020*, Palembang 20 Oct 2020 "Komoditas Sumber Pangan untuk Meningkatkan Kualitas Kesehatan di Era Pandemi Covid-19".

Wahyudi A, Sari M, Rajamin I, Arsri M. 2023. Evaluation of proximate analysis and yield production of watermelon in Lampung, Indonesia. *Biodiversitas Journal of Biological Diversity*. 24(11). https://doi.org/10.13057/biodiv/d241122

Xiang Y, Li Y, Luo X, Liu Y, Yue X, Yao, B. 2022. Manure properties, soil conditions and managerial factors regulate greenhouse vegetable yield with organic fertilizer application across China. *Front Plant Sci*. 13: 1009631. https://doi.org/10.3389/fpls.2022.1009631

Zhang S, Li Y, Jiang L, Han W, Zhao Y, Jiang X, Li J, Shi W, Zhang X. 2023. Organic fertilizer facilitates the soil microplastic surface degradation and enriches the diversity of bacterial biofilm. *Journal of Hazardous Materials*. 459: 132139. https://doi.org/10.1016/j.jhazmat.2023.132139