Vol. 9 No. 1 September 2025

ISSN : 2597 - 8713 (ONLINE)
ISSN : 2598 - 5167 (PRINT)

AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Improving Pakchoy (*Brassica rapa* L.) Growth and Yield in Stone Waste–Contaminated Soil Through Organic Amendments

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Article History: Received: May 11, 2025; Accepted: July 23, 2025

ABSTRACT

Rock flour (slurry), a by-product of the stone industry, contributes to soil degradation by causing soil compaction and reducing soil fertility. The sustainable strategies such as the application of organic amendments are needed to restore soil properties. The aim of this research to evaluate the effects of different organic amendments—rice husk biochar, straw compost, and goat manure—on the growth and yield of pakchoy (Brassica rapa L.) cultivated in stone waste–contaminated soil. This research used randomized block design with four treatments and five replications was employed: (P1) control (stone waste–contaminated soil without amendment), (P2) Stone waste–contaminated soil and husk biochar (1:1), (P3): Stone waste–contaminated soil and straw compost (1:1), and (P4): Stone waste–contaminated soil and goat manure (1;1). The results showed that goat manure significantly enhanced pakchoy growth parameters, including plant height, number of leaves, root volume, and plant weight. Goat manure promote the optimal plant growth through serve optimal planting media.

Keywords:slurry, soil compaction, straw compost.

1. INTRODUCTION

Cirebon Regency has become one of centers for natural stone industry in West Java. The rapid growth of this industry stimulate the local economic activity. On the other hand the existence of stone industry raises environment problems. During the process of cutting the craftsmen use water to cool the machine and smooth the stone. Stone waste as slurry discharged into irrigation channels has led to sedimentation, reduced water quality, and change the soil characteristic. Rock flour (slurry) is a by- product of natural stone industry, semi liquid waste and fine texture.

The accumulation of slurry on surface soil continuously is a main challenge for local agriculture system. Fine texture caused soil compaction significantly. Soil compaction increase bulk density, decrease soil porosity and affect plant growth (Shaheb et al., 2021). The accumulation of sediment also change the nutrient status of soil or imbalance soil nutrients (Danish et al., 2021). Furthermore (Nurfadilah et al., 2024) found that soil contaminated by natural stone waste had very low of nitrogen. It can be limiting factor in plant growth. So, there is need sustainable strategies

DOI: https://doi.org/10.55173/agriscience.v9i1.168

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that can restore soil productivity to support local agriculture system. One of strategies is used soil amendment.

Soil amendment defined as materials added to improve the soil characteristic both physics, chemical and biological soil. Soil amendment including organic, inorganic materials or combination of them. Organic matter have function to restore soil characteristic such soil structure, water holding capacity, cation exchangeable capacity, pH, and also source of microbe energy (Herlambang et al., 2019). Some organic matter including manure, rice straw and husk. Animal manure and compost as organic amendment widely used in degraded soil restoration, especially to improve soil organic matter (Omokaro et al., 2024) and rice husk biochar (Charloq, 2024). Soil organic matter can improve soil structure, increase microbial activity, and enhance nutrient availability. Each organic material has different content and characteristic that affects its ability as a soil amendment.

Pakchoy (*Brassica rapa*, L) is a popular vegetable that widely favored. This plant has a short life cycle and a shallow root system. As a leafy plant that well respond to changes of soil quality, pakchoy can provide a quick response to different types of soil amendment treatments as a rehabilitation effort in soil affected by natural stone waste industries. The aim of this study to investigate the effect of different types of organic amendment on the growth and yield of pakchoy cultivated on degraded soil espesially affected by natural stone waste industries.

2. RESEARCH METHOD

The research was conducted in Kuningan regency at $6^0$97'14" and 108^0,46'19 on November to December 2024. This research used randomized block design to compare the type's of organic amendment including rice husk biochar, straw compost and goat manure. There are four treathment and repeated five times. The treathment were P1: Stone waste–contaminated soil without amendment (control), P2: Stone waste–contaminated soil and husk biochar (1:1), P3: Stone waste–contaminated soil and straw compost (1:1), and P4: Stone waste–contaminated soil and goat manure (1;1).

Stone waste-contaminated soil was collected from a depth 0-30 cm. Parameters analysed were plant height, number of leaves at 10, 20, and 30 Day After Planting (DAP), root volume, root height, fresh weight and fresh weight consumption. Data were analyzed using ANOVA and post hoc analysis using Duncan (α = 5%)

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3. RESULT AND DISCUSSION

Soil Analysis

The preliminary soil analysis indicate that the experimental soil has a very low nitrogen content (0.10%), moderate levels of P_2O_5 dan K_2O, silt loam texture dominated by dust content at 69%, and a neutral pH (7.4). This soil analysis suggests that the limiting factors of the soil are nitrogen availability and a tendency towards fine soil texture. The preliminary soil analysis shown in Table 1.

Plant Height

Plant height is one of critical parameter during the vegetative phase, serving as a reliable indicator of plant physiological status and nutrient availability in planting medium. It is commonly used to know the impact of agronomic treatments on plant growth and nutrient availability. Plant height of pakchoy under different organic soil amendment shown in Table 2.

Table 1. Soil Analysis

Parameter	Value	
Sand	6%	Silt Loam
Silt	69%	
Clay	25%	
pH (H_2O)	7,4	Neutral
pH (KCl)	5,9	
N (Kjeldahl)	0,10%	Very Low
C/N Ratio	12	
P_2O_5 (Olsen)	14,8 ppm	Medium
K	52,5 ppm	Morgan
P_2O_5 (HCl 25%)	127,01 mg/100g	
K_2O (HCl 25%)	20,72 mg/100g	Sedang
CEC	13,99 cmol(+)/kg	Titrimetri

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At 10 DAP straw compost (P3) treatment have the highest of average plant height (11,40 cm) and its different than control (P1) significantly, although is not different significant with P2 and P4 treatment. Straw compost provided nutrient such nitrogen, potassium and phospor rapidly, which is those nutrient were important nutrient during the early of vegetative stage (Rosmakan and Yuwono, 2002). Straw compost also enhance the soil organic matter.

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Table 2. Plant Height At 10,20, and 30 DAP

Treatment	Plant Height (cm)		
	10 DAP	20 DAP	30 DAP
P1 (control)	9.76 a	12.30 b	18.60 bc
P2 (husk biochar)	9.90 ab	10.60 a	19.40 c
P3 (straw compost)	11.40 b	12.90 b	16.40 a
P4 (goat manure)	9.90 ab	17.10 c	17.10 ab

Note: Numbers followed by the similar letter not significantly different at 5% Duncan test level

However at 20 DAP the pattern of growth was changed. P4 (Stone waste–contaminated soil and goat manure) have the highest of average plant height (17.10 cm) and its different significant with other treatment. Finally at 30 DAP, the P2 (Stone waste-contaminated soil and husk biochar) have the highest of plant height (19,40cm). Biochar have capability of enhance the soil organic carbon and decreased bulk density (Idbella et al., 2024). Biochar have long term possitive impact to improve the properties of degraded soil.

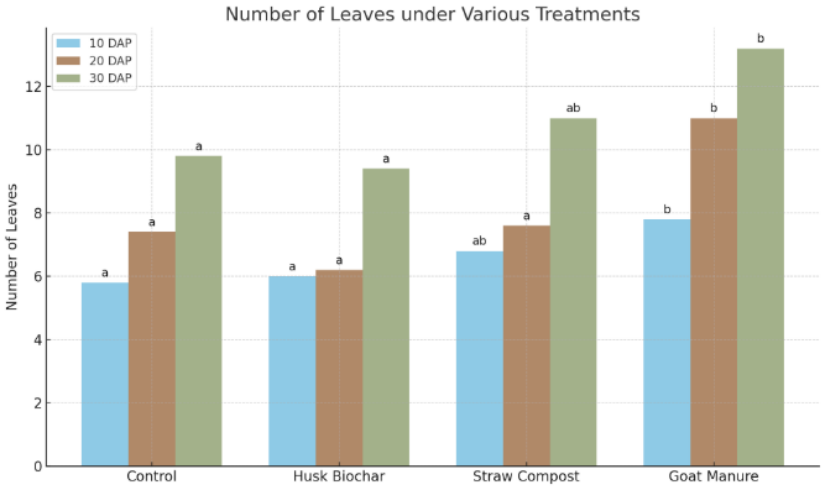
Number of Leaves

Leaves is essensial organ that play essensial role in photosyntetic process. Similar to plant height, number of leaves also serve as nutrient sufficiency, particularly nitogen availability. Soil anlysis result that planting medium have very low of nitrogen as 0,10%, which is it can be a limited factor in vegetatif phase especially to the growth of Pakchoy (*Brassica rapa* L) leaves Number of leaves shown in Table 3 and Pigure 1.

Table 3. Number of Leaves at 10, 20, and 30 DAP

Treatment	Number of Leaves		
	10 DAP	20 DAP	30 DAP
P1 (control)	5.80 a	7.40 a	9.80 a
P2 (husk biochar)	6.00 a	6.20 a	9.40 a
P3 (straw compost)	6.80 ab	7.60 a	11.00 ab
P4 (goat manure)	7.80 b	11.00 b	13.20 b

Note: Numbers followed by the similar letter not significantly different at 5% Duncan test level



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Pigure 1. Number of Leaves Under various Treatments

During the all observation periods, P4 treatment consistently resulted in highest number of leave. Altought in 10 and 30 DAP is not different significant with P3 which straw compost as soil amendment. Goat manure is organic amandement that rich macro and micronutrient and the decompotition of goat manure faster than other organic materials (Adekiya et al, 2021). This condition provide nutrient properly and enhance the growth of plant. Goat manure have nitrogen total as 2,5% (Suarmaprasetya & Soemarno, 2021) higher than straw compost and husk biochar. Nitrogen is part of chlorophyll structure and important to photosyntetic. Decreasing nitrogen supply reducing chloropyll content (Chen et al., 2024) and induced decreased photosynthesis (Kang et al., 2023). The adequate of nitrogen is critical of vegetatif growth, escpecially leaf growth dan biomass accumulation.

Root Volume and Root Lenght

Root is responsible to water and nutrient absorption. The performance of root system is influenced not only by nutrient availability but also by the physical properties such structure, bulk density and porosity of soil.

Table 4. Root Volume and Root Lenght

Treatment	Root Volume (ml)	Root Lenght (cm)
P1 (control)	1.80 a	10.40 a
P2 (husk biochar)	2.60 a	13.20 a
P3 (straw compost)	3.00 a	14.20 a
P4 (goat manure)	6.00 b	15.64 a

Note: Numbers followed by the similar letter not significantly different at 5% Duncan test level

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Based on Table 4 indicate that the application of soil amendments significantly influenced root volume but had no statistically significant effect on root length (Table 4). Among the treatments, the addition of goat manure most effective in increasing root volume of pakcoy when applied on stone waste-contaminated soil. This effect show the role of organic amendments to improving soil structure and aggregational also made favorable conditions for root growth.

Particuraly, goat manure improve soil porosity, reduces soil compaction, restore soil stucture and also nutrient availiblity of the soil (Aytenew & Bore, 2020). It made optimal condition of planting medium. In addition of organic amendments such as manure enhance soil nutrient content. The application of various organic materials has been reported to increase soil nitrogen (N) and phosphorus (P) levels, which are essential for root development (Maerere et al., 2001). Phosphorus, as a key component of ATP have esensial role in plant metabolism and root system development (Iswiyanto et al., 2022). Furthermore, phosphorus availability influences the formation of lateral roots and root hairs, which are critical for efficient nutrient uptake (Niu et al., 2013). Potassium (K) is essential for enlarging root systems and enhancing nutrient absorption. Adequate potassium availability promotes the translocation of photosynthates from leaves to roots and supports energy supply for root growth, ultimately improving root size, plant vigor, and quality (Sustr et al., 2019; Xu et al., 2021).

Plant Weight

Based on the research the application of organic amendments significantly affected both total fresh weight and fresh weight consumption of pakcoy (Table 4). The addition of goat manure as organic soil amendment on degraded soil had the highest fresh weight (50.60 g) and consumption weight as 45.60 g.

Table 5. Fresh Weight and Fress Weight Consumption of Pakchoy

Treatment	Plant Weight (g)	
	FW	CW
P1 (control)	26.80 a	20.46 a
P2 (husk biochar)	29.28 b	21.96 a
P3 (straw compost)	27.00 a	20.40 a
P4 (goat manure)	50.60 c	45.60 b

Note: FW: fresh weight, CW: consumption weight. Numbers followed by the similar letter not significantly different at 5% Duncan test level

The addition of goat manure as organic amendment consistenly increasing the growth and yield of pakchoy cultivated in degraded soil, including plant height, number of leaves, root volume,

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plant weight. Goat manure contain high nutrient such nitrogen (2.34%), phosphorus (0.73%), potassium (1.35%), and organic carbon (15.39%) (Charloq, 2024; Suarmaprasetya & Soemarno, 2021). These nutrient levels are higher than rice husk biochar and rice straw compost. The adequate nutrient availability, particularly of macronutrients essential to enhance photosynthesis, vegetative growth, and increase biomass production (Hasan et al., 2017).

Rice husk and rice straw compost are also organic amendments that contribute to improved soil quality through the addition of organic carbon and nutrient both macro and micro nutrient. In this research, their effects on growth and yield of Pakchoy cultivated in natural stone waste contaminated were limited. In line with (Harahap et al., 2020), that the addition of rice husk biochar and compost increasing C-organic dan total of nitrogen but not sufficiently improve the C/N ratio of incubated soil in short term and cultivated soil at 7 DAP. One possible reason is their high carbon nitrogen (C/N) ratio, rich husk and straw compost has higher C/N ratio than goat manure. The effectiveness of organic amendments depends not only on their chemical composition but also on their specific properties such the decomposition, quality also stucture of organic matter, and the method of application. Therefore, the selection and management of organic amendments must consider these factors to ensure that they contribute optimally to soil fertility and plant productivity.

4. CONCLUSION

Stone waste-contaminated soil, one of degraded soil that requires rehabilitation. Organic amendment such rice husk, straw compost and goat manure can serve as alternatives to improve soil quality. Among these, goat manure significantly enhances the growth and yield of pakchoy *(Brassica rapa* L.), as evidenced by increased plant height, number of leaves, root volume, and total biomass. Goat manure increasing the growth and yield of pakchoy cultivated in stone waste-contaminated soil, including plant height, number of leaves, root volume, plant biomass. Goat manure rich of maro and micro nutrient, as well as its ability to improve soil structure and reduce compaction, thereby creating more favorable conditions for optimal pakchoy growth.

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