

The Effect of Mycorrhizal Biofertilizer Application on the Growth of Pakcoy (*Brassica rapa* L.)

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Abstract: Pakcoy (*Brassica rapa* L.) is a vegetable crop that can be cultivated in limited areas, including polybags. Arbuscular mycorrhizal fungi are considered a biological fertilizer that can support nutrient uptake and plant growth through a mutualistic association with plant roots. This study aimed to determine the effect of different doses of arbuscular mycorrhizal biofertilizer on pakcoy growth and to identify the treatment that produced the best growth response. The study used a quantitative approach with a non-factorial Completely Randomized Design consisting of five treatments and four replications, resulting in 20 experimental units. The treatments were P0 (550 g organic humus soil without mycorrhiza), P1 (5 g mycorrhiza + 545 g soil), P2 (10 g + 540 g soil), P3 (15 g + 535 g soil), and P4 (550 g pure mycorrhiza). Observations were conducted every seven days from 7 to 49 days after planting. The observed parameters were plant height, number of leaves, fresh weight, and root length. Analysis of variance showed that all treatments had no significant effect on the observed parameters. Descriptively, P4 produced the highest plant height at 17.38 cm, P1 produced the highest number of leaves (9.50) and fresh weight (10.08 g), while P3 produced the longest roots (9.63 cm). The results indicate that mycorrhiza application did not significantly improve pakcoy growth when the growing medium was already sufficiently fertile.

Keywords: Pakcoy, Arbuscular Mycorrhiza, Plant Growth, Biofertilizer, ANOVA

INTRODUCTION

Indonesia is an agrarian country with substantial biological resources, and the agricultural sector plays an important role in food and horticultural production. One horticultural crop that is widely consumed is pakcoy (*Brassica rapa* L.), a vegetable belonging to the Brassicaceae family. Pakcoy is adaptable to various growing conditions and can be cultivated in limited spaces using containers or polybags. However, cultivation in polybags may encounter limitations related to growing-media conditions and root development, particularly when the medium becomes compact over time (Harahap et al., 2024; Sinaga et al., 2023; Diantari et al., 2023).

Pakcoy has nutritional value because it contains protein, carbohydrates, vitamins, and minerals. Increasing public consumption of vegetables creates a need for cultivation practices that can maintain productivity while supporting safer and more sustainable production. The use of organic fertilizers has therefore received attention as an alternative to excessive reliance on inorganic fertilizers. Organic materials can contribute to improvements in the physical, chemical, and biological properties of soil (Bertham et al., 2022; Harahap et al., 2024).

One biological fertilizer that has been considered for plant cultivation is arbuscular mycorrhiza. Mycorrhiza forms a mutualistic association with plant roots and can support nutrient acquisition, particularly phosphorus, through the development of fungal hyphae. The association may enlarge the effective absorbing area of roots and help plants obtain nutrients and water from soil areas that are less accessible to ordinary roots (Dwitomo et al., 2023; Sianturi, 2022). Mycorrhiza may also contribute to plant tolerance to environmental stress and support root development (Fadhli et al., 2021).

The expected role of mycorrhiza is supported by previous findings included in the present study. Harahap et al. (2024) reported that mycorrhiza treatment affected several growth responses in mustard, including plant height, leaf number at a particular growth stage, and fresh weight. Nada et al. (2021) also reported that mycorrhiza influenced the growth of green mustard, with a 20 g per plant treatment producing better responses in leaf number, fresh weight, and phosphorus-related variables than several other treatments. These findings suggest that the effectiveness of mycorrhiza can vary according to plant species, treatment dose, and growing-medium conditions.

In contrast, the response of pakcoy to mycorrhiza cannot be assumed to be identical to the response of other Brassica crops. Plant growth is influenced by internal characteristics and environmental factors, including temperature, humidity, climate, water availability, and nutrient availability (Sanjaya et al., 2022). The effectiveness of mycorrhiza is also related to soil fertility and the availability of nutrients, particularly phosphorus and nitrogen. Thus, the use of a nutrient-rich growing medium may reduce the visible contribution of mycorrhizal symbiosis to plant growth (Dwitomo et al., 2023; Putu et al., 2021).

The present study was conducted to examine this issue specifically in pakcoy cultivated in organic humus soil. The research tested four levels of mycorrhizal addition and one control treatment, with plant height and leaf number observed periodically and fresh weight and root length measured at harvest. This design provides a direct assessment of whether different amounts of mycorrhiza produce measurable differences in pakcoy growth under the growing-medium conditions used in the study.

The objective of this study was to determine the effect of 5 g, 10 g, 15 g, and 550 g of arbuscular mycorrhiza used as growing-medium treatments on pakcoy growth and to determine whether any treatment produced the best growth response. The findings are expected to provide empirical information regarding the use of mycorrhiza in pakcoy cultivation, particularly when the growing medium already contains sufficient nutrients.

METHOD

This study used a quantitative experimental approach with a non-factorial Completely Randomized Design (CRD/RAL). The research was conducted in the Pondok Pesantren Al-Muhajirin 1 Bahrul Ulum environment, Tambakberas, Tambakrejo Village, Jombang District, Jombang Regency. The research period covered approximately two months, with planting and observations extending from November 2025 to January 2026.

The experimental material consisted of Nauli F1 pakcoy seeds from Panah Merah, organic humus soil produced by Barokah Jaya, and arbuscular mycorrhizal biofertilizer. The main equipment included 18-cm-diameter polybags, a ruler, digital weighing scale, watering equipment, documentation equipment, and stationery. The same pakcoy variety and the same base growing medium were used across treatments to reduce variation among experimental units.

Five treatments were applied and each treatment was replicated four times, giving 20 experimental units. P0 served as the control with 550 g of organic humus soil and no mycorrhiza. P1 consisted of 5 g mycorrhiza and 545 g soil; P2 consisted of 10 g mycorrhiza and 540 g soil; P3 consisted of 15 g mycorrhiza and 535 g soil; and P4 consisted of 550 g pure mycorrhiza. These

treatment compositions follow the experimental design reported in the thesis and are retained without modification.

Before planting, seeds were selected by soaking them for approximately one hour, and seeds considered suitable were used. Growing media were prepared according to treatment and placed into labelled polybags. Mycorrhiza was added when the growing medium was placed into the polybag. Each polybag was prepared with planting holes approximately 2 cm deep, and one seed was placed in each hole. Plant maintenance included regular watering, manual weed removal, and pest and disease control when necessary.

Data collection was conducted every seven days at 7, 14, 21, 28, 35, 42, and 49 days after planting (DAP/HST). The measured variables were plant height (cm), number of leaves (leaves), root length (cm), and fresh weight (g). Plant height was measured vertically from the soil surface to the highest growing point. Leaf number was determined by counting fully formed leaves. Root length was measured from the root base to the root tip at harvest, while fresh weight was measured by weighing the fresh plant material at harvest.

The data were analyzed using analysis of variance (ANOVA) to test whether differences among treatments were statistically significant. The decision criterion used the 5% level, with the calculated F value compared with the 5% F table value. When a significant treatment effect was present, the research plan specified continuation with the Least Significant Difference (LSD/BNT) test. Because the ANOVA results for all observed parameters were non-significant, no further test was conducted.

RESULTS AND DISCUSSION

Plant Height

Plant height increased throughout the observation period in all treatments. The average values at 49 DAP were 16.88 cm for P0, 17.00 cm for P1, 16.88 cm for P2, 16.50 cm for P3, and 17.38 cm for P4. Thus, P4 had the highest descriptive value, although the difference among treatments was small.

Table 1. Mean plant height of pakcoy during observation (cm)

Treatment	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP
P0	6.00	6.75	10.38	12.00	13.13	16.38	16.88
P1	6.00	8.25	9.50	10.75	13.25	16.13	17.00
P2	5.50	7.75	9.75	10.63	11.63	15.63	16.88
P3	6.00	8.38	11.13	12.75	13.00	15.75	16.50
P4	6.00	8.13	10.63	11.38	13.13	15.75	17.38

The growth pattern was relatively uniform among treatments, with the most pronounced increase occurring between 35 and 42 DAP. ANOVA results showed that the treatment effect was not significant at every observation time. At 49 DAP, for example, the calculated F value was 0.193252, lower than the 5% F table value of 3.055568. The same non-significant pattern occurred at 7, 14, 21, 28, 35, and 42 DAP.

The absence of a significant response suggests that the additional mycorrhiza did not produce a sufficiently strong difference in plant height under the conditions of this experiment. Although P4 reached 17.38 cm compared with 16.88 cm in the control, this numerical difference cannot be interpreted as a treatment effect because the ANOVA did not establish statistical significance. The finding is consistent with the thesis discussion that mycorrhiza can be more effective in nutrient-poor or marginal soils than in fertile media (Dwitomo et al., 2023).

Another possible explanation is the nutritional condition of the growing medium. The organic humus soil used in the experiment was reported to contain N 25%, P 7%, and K 9%, with a pH of 6. Under a sufficiently fertile medium, plants may obtain nutrients directly, reducing the relative need for mycorrhizal hyphae to facilitate nutrient acquisition. This interpretation is also consistent with the thesis discussion citing Putu et al. (2021), which emphasizes the importance of adequate nutrient availability for plant growth, and Sanjaya et al. (2022), who describe the contribution of both plant-internal and environmental factors to growth.

Number of Leaves

Leaf number increased from the early establishment phase to harvest. At 49 DAP, P0 had an average of 8.75 leaves, P1 had 9.50 leaves, P2 had 8.25 leaves, P3 had 8.75 leaves, and P4 had 8.00 leaves. Descriptively, P1 showed the highest number of leaves.

Table 2. Mean number of leaves of pakcoy during observation

Treatment	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP	49 DAP
P0	2.00	4.00	6.50	7.50	6.75	7.75	8.75
P1	2.00	4.50	6.75	7.25	7.00	8.75	9.50
P2	2.00	4.25	5.50	6.25	7.00	7.00	8.25
P3	2.25	4.25	6.00	6.25	6.75	7.75	8.75
P4	1.75	4.00	6.25	6.50	6.50	7.00	8.00

ANOVA showed that mycorrhizal treatment did not significantly affect leaf number at any observation time. At 49 DAP, the calculated F value was 0.935294, compared with an F table value of 3.055568. Therefore, the descriptive advantage of P1 cannot be regarded as a statistically established treatment effect. This result agrees with the study discussion in the thesis citing Dwitomo et al. (2023), in which arbuscular mycorrhiza did not produce a significant response in leaf number.

Leaf development is closely related to nutrient availability, especially nitrogen, because the observed harvest product is primarily the vegetative part of the plant. The thesis relates this condition to Nugroho et al. (2024), who emphasized that a suitable growing medium should provide balanced nutrients and appropriate pore conditions. Because the organic humus medium in the present study was already nutrient-rich, the additional mycorrhiza may not have produced a sufficiently contrasting nutrient-acquisition advantage. The relatively close growth curves across treatments support this interpretation.

Fresh Weight

Table 3. Fresh weight of pakcoy at harvest (49 DAP)

Treatment	U1 (g)	U2 (g)	U3 (g)	U4 (g)	Mean (g)
P0	6.8	8.8	7.2	6.7	7.38
P1	6.1	6.6	10.4	17.2	10.08
P2	7.3	4.4	5.4	4.3	5.35
P3	8.3	5.2	5.2	6.2	6.23
P4	5.4	3.1	3.1	7.6	4.80

Fresh weight showed a wider descriptive variation than plant height and leaf number. P1 had the highest mean fresh weight (10.08 g), followed by P0 (7.38 g), P3 (6.23 g), P2 (5.35 g), and P4 (4.80 g). Nevertheless, the ANOVA result remained non-significant: F calculated was 2.43,

lower than the 5% F table value of 3.05557. Consequently, the higher mean in P1 should be interpreted as a descriptive tendency rather than evidence that 5 g mycorrhiza was the statistically optimal dose.

The fresh-weight result is consistent with the findings reported by Harahap et al. (2024) in the thesis, where mycorrhiza did not significantly affect fresh weight. Fresh biomass is related to the accumulation of vegetative organs and water status, so variation in plant height and leaf development can contribute to differences in fresh weight. The present experiment also used a fertile organic humus medium containing N, P, and K, which may have supplied sufficient nutrients for biomass formation without a strong dependence on mycorrhizal assistance.

The lower descriptive fresh weight under P4 also illustrates that increasing the amount of mycorrhiza did not automatically improve biomass. This observation reinforces the importance of matching the biological fertilizer treatment with the physical and chemical condition of the growing medium. The thesis findings therefore do not support a simple assumption that a higher mycorrhizal dose will always result in higher pakcoy biomass.

Root Length

Table 4. Root Length

Treatment	U1 (cm)	U2 (cm)	U3 (cm)	U4 (cm)	Mean (cm)
P0	8.0	6.5	10.0	6.0	7.63
P1	5.0	10.0	13.0	10.0	9.50
P2	9.0	6.0	10.0	7.0	8.00
P3	9.5	12.0	6.0	11.0	9.63
P4	5.0	6.0	9.0	8.0	7.00

At harvest, P3 produced the longest mean roots (9.63 cm), followed by P1 (9.50 cm), P2 (8.00 cm), P0 (7.63 cm), and P4 (7.00 cm). However, the ANOVA result showed no significant effect, with F calculated of 0.974888 compared with the F table value of 3.055568. Thus, the apparent advantage of P3 was not statistically sufficient to establish a treatment difference.

The result is comparable to the thesis discussion of Harahap et al. (2024), which also reported no significant effect of mycorrhiza on root length. Dwitomo et al. (2023) explains that mycorrhiza tends to work more effectively under nutrient-poor or marginal conditions. In a fertile

medium, the control plants may already obtain adequate nutrients through their own root systems, reducing the contrast between plants with and without mycorrhiza.

Root development may also have been constrained by the physical growing space. The experiment used polybags with an 18 cm diameter, so root expansion was limited by the container. Although P3 had a descriptive mean of 9.63 cm compared with 7.63 cm in P0, the difference remained statistically non-significant. Therefore, the result suggests a possible tendency rather than a confirmed dose response.

Overall Statistical Response

Table 5. Selected ANOVA results for mycorrhizal treatments

Parameter	Observation	F calculated	F 5%	Decision
Plant height	7 DAP	1.448898	3.055568	Not significant
Plant height	49 DAP	0.193252	3.055568	Not significant
Leaf number	49 DAP	0.935294	3.055568	Not significant
Fresh weight	49 DAP	2.430000	3.055570	Not significant
Root length	49 DAP	0.974888	3.055568	Not significant

Across all measured variables, the calculated F values were lower than the corresponding 5% F table values. The statistical pattern is therefore consistent: the tested mycorrhizal doses did not produce a significant difference in pakcoy growth under the experimental conditions. Because no significant treatment effect was identified, the planned LSD/BNT follow-up test was not performed. This is an important finding because it indicates that the effectiveness of a biological fertilizer cannot be evaluated only from descriptive differences in means; statistical evidence and the characteristics of the growing medium must also be considered.

The overall finding also contributes a more specific interpretation of previous studies. Earlier research cited in the thesis reported positive mycorrhizal responses in other crops or under different combinations of growing media and fertilizers (Harahap et al., 2024; Nada et al., 2021; Sugiana et al., 2023). The present study, however, demonstrates that such responses are not automatically reproduced in pakcoy grown in a fertile organic humus medium. The practical implication is that mycorrhizal application should be considered in relation to nutrient status, root space, plant genotype, and growing conditions rather than treated as a universally increasing input.

CONCLUSION

The application of arbuscular mycorrhizal biofertilizer at 5 g, 10 g, 15 g, and 550 g did not significantly affect the growth parameters of pakcoy (*Brassica rapa* L.), including plant height, number of leaves, fresh weight, and root length. Descriptively, P4 produced the highest plant height (17.38 cm), P1 produced the highest leaf number (9.50 leaves) and fresh weight (10.08 g), while P3 produced the longest roots (9.63 cm). However, none of these descriptive differences was statistically significant. The absence of significant effects was associated in the thesis with the sufficiently fertile organic humus growing medium, which contained N 25%, P 7%, and K 9%, allowing plants to obtain nutrients directly and potentially reducing the relative effectiveness of mycorrhizal symbiosis. Future studies should consider nutrient-poor or marginal media, larger growing containers or field conditions, and microscopic assessment of root colonization to verify whether mycorrhiza establishes an effective association with pakcoy roots.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study or its publication.

Generative AI Use

The authors declare that no generative artificial intelligence (AI) tools were used in the preparation, writing, analysis, or development of this manuscript.

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